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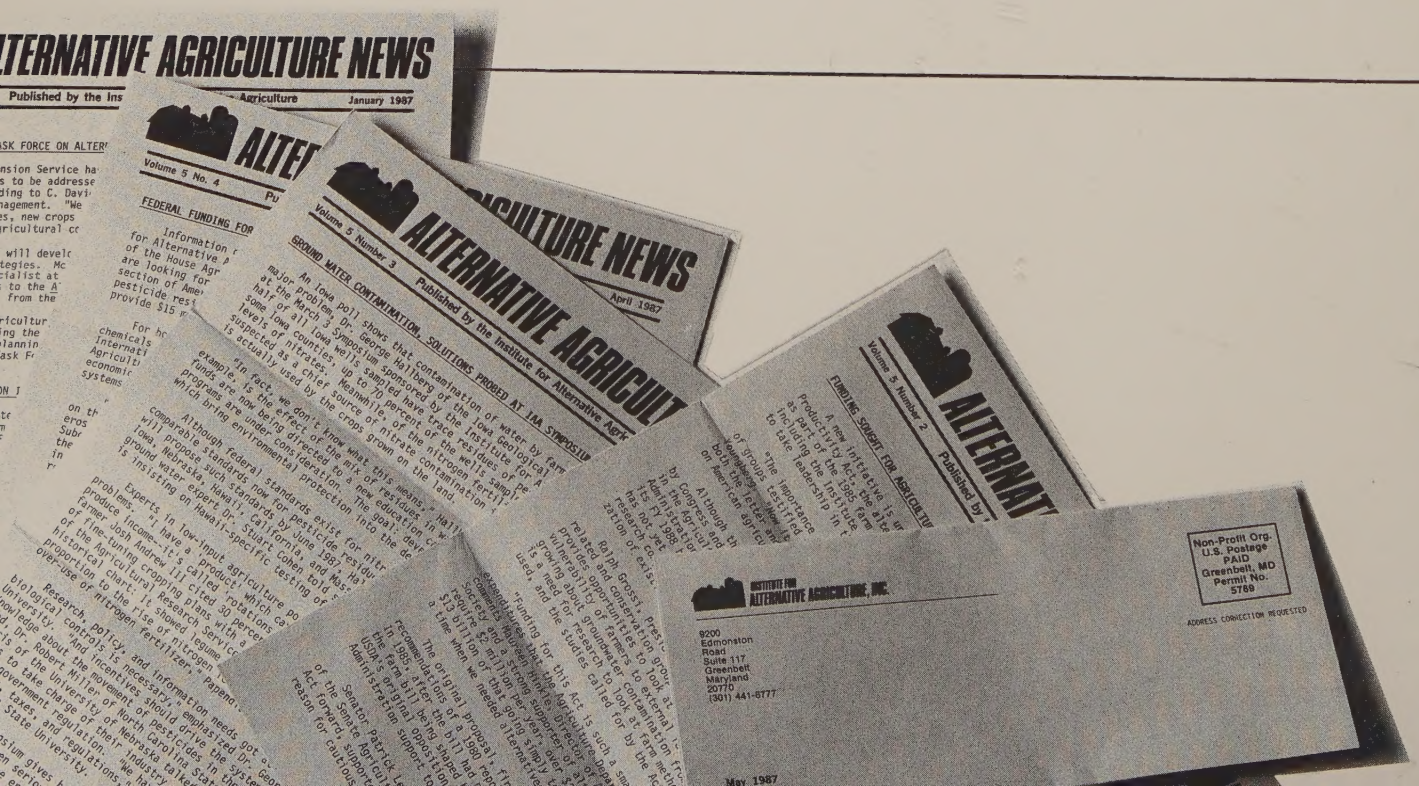
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Institute Information

The Institute for Alternative Agriculture is a nonprofit, tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low-cost, resource-conserving and environmentally-sound farming methods. It works closely with producer groups, public research and education institutions, and government agencies in promoting a sustainable agriculture system.

Its programs include providing a national information clearinghouse, serving as a voice for sustainable agriculture in Washington, and developing and implementing research and educational outreach programs. It holds an annual scientific symposium and publishes a monthly newsletter.

The Institute is governed by a grass roots Board of Directors, which includes several commercial-scale organic farmers, and maintains a small professional staff. It is supported by memberships and donations and grants from foundations, corporations, and individuals.

Cover Photo

Regional Extension Specialist Karen Talarczyk and local farmers confer at Lee Montgomery's on-farm demonstration plot near Argyle, Wisconsin. Lee and other farmers not only manage demonstration projects but also serve on regional advisory councils for the Nutrient and Pest Management (NPM) program, a University of Wisconsin—Extension program affiliated with the Center for Integrated Agricultural Systems (see p. 111). Photo by Laura Ward Good, University of Wisconsin, Madison, WI.

Opinion: Alternative agriculture in the Third World

Ricardo Henrique Silva Santos and Irene Maria Cardoso

Alternative agriculture has been attracting increased interest in the media, research centers and universities, and worldwide public opinion. So, too, non-governmental organizations of the First World have been increasing their support of alternative agriculture for underdeveloped countries, such as Brazil.

However, "alternative agriculture" may mean different things in the First and Third Worlds. We need to answer a simple and direct question: "Alternative" to what?

In a general way, the complex group of agriculture practices called "alternative" attempt to achieve several goals:

- To eliminate or decrease as much as possible the use of fertilizers and pesticides of industrial origin, thereby reducing harmful residues in the soil, groundwater, air and food;
- To preserve the chemical and biological integrity of the soil;
- To integrate diverse agricultural production processes, to recycle residues, and to reduce energy costs, using techniques such as composting, green manuring, integrated pest management, reduced tillage, and mulches;
- To produce more nutritious food.

However, these goals and practices are not an objective in their own right. The primary and fundamental purpose is to improve human living conditions through a food supply and a healthy environment in harmony with the laws that govern life on the planet. With this as the starting point, what should be done for an underdeveloped country such as Brazil? What is the current situation to which we seek an alternative?

The following are some relevant facts about Brazil. The 90% of Brazilian farms with less than 100 ha account for only 21% of cultivated land, whereas the 0.84% with more than 1,000 ha account for 44% (IGBE, 1985). Only one-fourth of agricultural credit goes to small producers who produce about 70% of agricultural products for the domestic market; the remaining three-fourths goes to medium and large proprietors (DIEESE, 1990). Production of grain (corn, beans, rice and soybeans) fell from 63 million tons in 1988-89 to 50 million tons in 1990-91. Three-fifths of the labor force earn a monthly salary of less then $175, and 70% of the people are undernourished. Also, the illiteracy rate is among the highest in the world (DESER, 1991).

A holistic vision cannot disregard these facts. Clearly, most of the population has not participated in Brazilian agriculture's development spurt, and efforts to improve the quality of life of Brazilian society must concentrate on the significant portion of the population that was left out.

Besides the obvious differences in climate, soils, and technology between the First and Third Worlds, differences in the structure of society may inhibit efforts to improve the quality of life if proposals for alternative agriculture are transferred without critical analysis. Also, technology reflects the society's cultural development, and is not simply the result of mechanically applying research data.

A clear, direct example is provided by the argument for higher prices for organic products as a practical way to encourage conversion to alternative systems. This argument is valid for developed countries, where salary levels are reasonable and people have the option of choosing what kinds of products they buy. However, in Brazil the argument is immoral, because only a tiny portion of the population could afford more expensive organic products. This argument leads to elitism, excluding even more low income people from the improvement in quality of life that is the goal of alternative systems.

Given this background, significant among the many versions of alternative agriculture in Brazil is one that seeks a new agricultural paradigm that can improve the quality of life for small producers and non-landowners. Increasingly it is being recognized that an alternative to conventional Brazilian agriculture must include redistribution of land, a reorientation of the extension and credit systems, and a major commitment of resources to scientific and technological research on low-input methods. It also must include government support to small producers for organizing and commercializing their production, and redistribution of income of urban workers to increase their purchasing power.

These needs seem largely solved in the First World, but they are crucial for those who want a holistic alternative agriculture in Brazil. On one hand, these ideas may limit the range of practices that should be proposed, making the problem even more complex. On the other hand, they hold open to the majority of Brazilian people the possibility of a better life.

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Research and agriculture: Challenging the public system

David B. Danbom

Abstract. *The publicly sponsored agricultural research system in the United States has always had to deal with the tension between public expectations and scientific practices and standards. The equilibrium it established between those two contradictory demands has been unraveling since the 1960s. The contemporary challenge to the system is to redefine its public and scientific roles in an environment of rapid scientific change and of public debate and disunity.*

Key words: agricultural experiment stations, LISA, public agricultural research, scientific disciplines, agricultural technology

The publicly sponsored agricultural research system in the United States has always coped with a tension embedded in its very essence. On one hand, the system is scientific, and thus at least theoretically is governed by scientific standards and guided by the search for scientific truth. On the other, it is publicly supported, and therefore must respond to public needs, demands, and criticisms that do not necessarily conform to accepted scientific standards and practices, and may even contradict them.

The tension between scientific standards and public demands, which would have been challenging in any case, was exacerbated by the circumstances under which the agricultural research system originated. This system, as embodied in the United States Department of Agriculture and a land-grant complex created by the Morrill Land-Grant College Act of 1862 and the Hatch Act of 1887, was a curiosity. Farmers were the people who were supposed to be served by the system, but most did not want a scientifically active USDA, and especially not agricultural colleges or experiment stations. The states, however, always looking for federal land grants and money, were interested. Agricultural policymakers, concerned about the effects of backward, unprofessional farmers on the nation's economic health, were enthusiastic. And politicians, desirous of doing something to stem the rising tide of agrarian radicalism without disrupting the economic arrangements that helped spark that radicalism, were receptive. Only the farmers were relatively uninterested and uninvolved (Dupree, 1957; Marcus, 1985; Kerr, 1987).

A second curious circumstance in the creation of the agricultural research system was that the scientific disciplines that would be represented were, as a rule, rudimentary and inchoate. Chemistry was the only early agricultural discipline that could be said to have been mature. Botany and zoology were both established, but were undergoing wrenching paradigm shifts. Others—microbiology, plant pathology, agronomy, and genetics, for example—were only beginning to search for firm foundations. Congress, so often damned for its lack of foresight, had created scientific institutions for which scientists were unready (Rossiter, 1979).

These unusual circumstances presented both a great risk and a great opportunity to the people in the system. They had the opportunity to define a public and create public support and to delineate and claim a scientific territory. They risked a failure that would leave them without public support or scientific legitimacy or both. Their efforts to define and satisfy a public and to build and maintain scientific respectability have continued for over a century.

Building Public Support

The infant agricultural research establishment took several steps to build support among the public in general and among farmers in particular, especially at the state level, where public backing was crucial. Early experimentation was practical almost to the point of being pedestrian. Variety testing and fertilization experiments, for example, were designed to show farmers that the system would be immediately and clearly useful to them. Outreach activities also were important. Experiment station scientists commonly participated in farmers' institutes, which were programs offered in rural areas in winter months, and in short courses held at land-grant institutions. Researchers cooperated eagerly with railroads sending trains promoting better seed or dairy farming through their states.

Some early experiment stations encouraged farmers to undertake experiments and share the results with professional scientists, and others set up model farms with cooperating farmers. Although agricultural researchers candidly admitted that most such ventures at best were of dubious scientific worth, their public relations value justified the effort. (For the attempts of one experiment station to build public support, see Danbom [1990]).

Probably the most enduring result of this early popularization effort was that it created supportive client groups among farmers. Recognizing early that farmers were too amorphous a group and had too

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many divergent interests to be organized effectively or to provide coherent support for agricultural science, "research entrepreneurs" such as Wisconsin's W. A. Henry and California's Eugene Hilgard strove to serve the needs of producers of special, limited crops and animal products, tying their interests to that of the research establishment. Sometimes commodity groups already existed, and sometimes research entrepreneurs had to create them, but in either case, long-lasting, mutually supportive, and controversial relationships were developed in which some farmers received research that was especially relevant and researchers received dependable public support (Rosenberg, 1971).

The close relationship between organized clients and research institutions had several implications. It tended to commit agricultural scientists to practical, problem-oriented research on particular animals or crops. Also, it led researchers to neglect farmers with whom they did not have special relationships. Finally, it contributed to the balkanization of research institutions, because in practice, mutually supportive relationships usually were established between client groups and particular college or experiment station departments. Although none of these developments was fully anticipated or desired by research entrepreneurs, the compensation for them came in enhanced and focused political support.

The relationship between scientific institutions and narrow client groups has been the most enduring in the public research system. Indeed, it has generally become stronger over time, especially during the 1930s when commodity oriented federal farm programs implicitly encouraged the development of commodity groups, and after World War II, when the producers of almost every crop and animal were organized.

Another interesting facet of the early agricultural research system was its involvement in what might be called "regulatory" work. Experiment station scientists analyzed and certified fertilizer and seed, and provided the scientific expertise for evaluating such diverse items as food and drug products and paints. Part of the reason that the agricultural research institutions did regulatory work was that in many states they were the main repository of public scientific knowledge. But such analytical work also allowed agricultural researchers to demonstrate their public usefulness and build public support. Although the research system commonly argues that it mainly serves consumers, early in this century that claim would have not been met with the skepticism that so often meets it today (Kerr, 1987; Danbom, 1990).

Achieving Scientific Respectability

Although the activities of early research entrepreneurs were effective in developing public support for agricultural science, particularly at the state level, they necessarily involved a tradeoff that was disturbing to many people interested in the future of the enterprise. Early leaders in publicly sponsored agricultural research, such as W.O. Atwater and A.C. True of the United States Department of Agriculture's Office of Experiment Stations, worried that an overemphasis on practical research and regulatory work by land-grant colleges and experiment stations threatened to compromise their scientific credentials and respectability (Nye, 1983; Kirkendall, 1986; Kerr, 1987).

Agricultural science already was held in contempt by researchers in more established disciplines, for complex reasons. One was that despite the hoary canons of the agrarian myth, farmers were not highly respected in American society. The scientists who served farmers were inevitably denigrated along with them. Another was that the research done in public agricultural facilities overwhelmingly was practical and applied, and thus was considered pedestrian by elite scientists. The agricultural disciplines generally were young, and many did not rest on firm scientific foundations, another reason that the older sciences held them in contempt.

Still another cause for disrespect was the tendency of agricultural scientists to create new disciplines, such as agronomy and animal science, rather than expanding established and accepted disciplines such as botany and zoology, and their related practice of training young scientists in these disciplines in a relatively closed and insulated land-grant system. The decision of the Carnegie Foundation in 1906 not to allow the land-grant schools to participate in its faculty retirement program because they were not fully legitimate institutions of higher education underscored the contemptuous attitude of the scientific elite (Savage, 1953; Veysey, 1965).

Atwater, True, and other like-minded research administrators believed that the long-term health of the research system demanded vigorous scientific upgrading. As long as the agricultural sciences were viewed as inferior they would never attract first-rate scientific minds. Nor would promising young scientists enter an endeavor in which the research was overwhelmingly applied, or in which they were expected to present farmers institutes or do the sort of regulatory work that technicians could do. But if promising young scientists did not come into the system, it could not be expected to make the kinds of scientific breakthroughs that ultimately would justify the investment the public had made in it.

The friendly critics of the system urged a new dedication to pure research, a reduction of teaching and extension responsibilities for land-grant scientists, and an end to regulatory work. Their goals were furthered by two important pieces of legislation passed early in this century. The Adams Act (1906) provided federal funds to free agricultural scientists from some teaching responsibilities so that they could undertake basic research; the Smith-Lever Act (1914) freed them of extension responsibilities by providing federal support for the county agent system (Rosenberg, 1964; Danbom, 1979).

These laws, along with constant prodding, resulted in some significant changes in most state experimental facilities by the early 1920s. Researchers rarely undertook extension work, and the reduction of their teaching responsibilities gave them more time for experiments. Most experiment stations were on their way to jettisoning regulatory responsibilities, if they hadn't done so already, thereby gaining scientific legitimacy but losing an important tie to the public in the process.

Other realities did not change. State facilities, faced with political challenges that the USDA and elite scientists did not always understand fully, maintained close relationships with agricultural client

groups. To serve and satisfy these clients, experiment stations and land-grant schools necessarily emphasized applied, practical research to a degree that critics considered excessive.

Achieving Equilibrium

The de facto compromise between the research entrepreneurship of the early years of publicly sponsored agricultural research and the self-conscious scientism of early twentieth century critics of the system evolved into a reasonably stable equilibrium after 1920. Research institutions continued to concentrate on the practical, production-oriented research their organized clients favored, but they ended the activities that had put them in frequent touch with broader segments of the farming and non-farming publics.

The shift was not always complete, nor was it easy. The agricultural depression of the 1920s, which intensified during the 1930s, led to much questioning of the degree to which the system served farmers. In the minds of many policymakers, an agricultural system awash in surpluses of basic commodities did not seem to need continued research aimed at increasing production. And many farmers, taking agricultural scientists at their exaggerated word that research had resulted in production increases during the teens, blamed the system for the surplus that plagued them. Even Secretary of Agriculture Henry A. Wallace, himself an agricultural researcher, criticized the system for its tendency to ignore the human consequences of its acts, arguing in 1934 that "science ... must be motivated by some conscious social purpose if civilization is to endure" (p. 4).

Provision of that "conscious social purpose" was not to be achieved by returning to the early days of the system, when idealistic young scientists turned their minds to the solution of all kinds of problems. Instead, socializing—or resocializing—the system involved creating places in it for agriculturally oriented social scientists. In 1925, Congress sought to help agricultural experiment stations reach back beyond commodity oriented client groups by passing the Purnell Act, which provided funds for research in economics, sociology, and domestic science. A decade later the Bankhead-Jones Act, a cover-all-bases law typical of the New Deal, provided further funding to assure investigation of the social and economic implications of agricultural research (Purcell, 1968; Kerr, 1987).

Those who hoped that such expressions of legislative intent would redirect the main thrust of agricultural research were sorely disappointed. Agricultural economists and rural sociologists were not usually vigorous advocates of groups unserved by the research system, nor did they offer probing criticisms of research policies. Their problem was that they were junior partners in the research endeavor, more or less forced on institutions that distrusted and patronized them. Their colleagues in the harder agricultural sciences viewed their work as pseudo-science at best; ironically, they were mimicking the treatment they themselves received from the more established scientific disciplines. In this environment, social scientists found it wise to be cooperative and compliant; when they were not they learned where the real power lay. (The experience of Walter Goldschmidt [1978] clearly showed the limitations under which social scientists in the research system usually labored).

The golden age for the agricultural research system began around 1940 and continued for about a generation. With the nation again at war, agricultural scientists' demonstrated ability to increase farm production was admired rather than criticized. The introduction of several new crop varieties developed by the system, especially of hybrid corn, provided a welcome payoff on the public's investment in research. The chemical and mechanical revolution in agriculture, which the system promoted and adopted, and in many ways initiated, promised a future of wonder and plenty.

To intellectuals, World War II showed how awful science could become. But to the public the scientific advances of the war years were more wonderful than frightening. For the postwar generation, progress was both good and inevitable, and science was its vehicle. Science would allow us to conquer disease, hunger, and the seemingly intractable realities of the physical world. Thousands of bright young people, eager to turn the future's promise into reality, streamed into graduate schools, often with the aid of the G. I. Bill.

The agricultural research system benefitted from this situation, just as did other scientific enterprises. The favorable public image of science and unprecedented economic prosperity combined to raise appropriations dramatically. The explosion in the number of young Ph.D.s allowed land grants and experiment stations to upgrade their staffs impressively. Bright young scientists participated in the work of revolutionizing American agriculture. New, bigger, and more versatile machines, an array of new, mostly petroleum-based pesticides and fertilizers such as 2,4-D, DDT, and anhydrous ammonia, and ever-improving crop varieties and animal breeds multiplied the productivity of American farmers and promised to banish hunger from America and even the world, either through the export of surpluses or the export of techniques to spark a "Green Revolution" (Schlebecker, 1975; Shover, 1976; Fite, 1981).

It was a heady time for agricultural science, but one that had some overtones that in retrospect were ominous. The traditional client base for the system shrank dramatically during the quarter century after World War II, eroded by the very increases in productivity that the scientists trumpeted. Few within the system were very concerned that the number of farmers was dwindling. Those who remained generally were more productive, professional, and prosperous, and from the perspective of political support, the system compensated for the dwindling number with fuller and more extended organization of commodity groups. Those who spoke for agricultural research also argued that they mainly served consumers anyway, and that consumers benefitted from food that was cheap, abundant, and available in impressive variety to most people most of the time. While appealing to the amorphous consumer allowed the system to proclaim its social utility, consumers did not provide the dependable and certain support of a client group. In partial compensation, many research entities strengthened and extended their financial and political ties to agribusiness, which ex-

panded dramatically in the new agricultural world of machines, chemicals, and commercially produced seed varieties.

The comfortable environment of the postwar years led the agricultural research system increasingly to become an "island empire" (Mayer and Mayer, 1974). Comfortable and secure, the system too often withdrew into itself, setting and meeting its own standards, maintaining its own disciplines, and ignoring other sciences, the rest of the academic world, and even public criticisms that it found unpleasant.

A Time of Troubles

The comfortable, even smug, postwar years left the agricultural research system ill-prepared for the many challenges that began in the 1960s and that emerged full-blown in the following decade. Within a few years, the agricultural research system moved from being a revered institution, as little questioned as apple pie or motherhood, to an embattled giant assailed by enemies from without and undermined by critics within.

One of the problems faced by the system involved the unraveling social consensus that progress was good and science was beneficial. Rachel Carson's *Silent Spring*, published in 1962, opened a long, acrimonious debate over the effect of agricultural chemicals on the environment. Since then, the debate has broadened from chemicals and the environment to issues of food safety, nutritional quality, animal rights, and the sustainability of an energy intensive system that seems too often to violate the principles of balance in a natural world. It was ironic for a system stressing its devotion to "consumers" that many organizations critical of agricultural research were "consumer" groups. Because consumers lack self-consciousness and do not care much, anybody is free to use them.

Rather than being a fad, as many in the system fervently hoped, this line of criticism has become a permanent fixture of public policy discourse. Environmentalism is firmly established, and nutrition and food safety issues command intense public interest. The fact that the National Research Initiative, included in the 1990 Farm Bill, earmarked funds for research in such areas as the environment, food quality and safety, nutrition, and health clearly indicates the degree to which these concerns have become accepted and legitimized. Moreover, some alternative agriculturalists who once were regarded as kooks have become respected commentators on the agricultural scene. An increasing number of farmers, beset by a vicious cost-price squeeze, are thinking about and even practicing alternatives to the prevailing system, and experiment stations have responded to the demands of clients and the inducements of the 1985 Farm Bill to initiate experimentation in low-input sustainable agriculture (LISA) (Kerr, 1987, 1988).

Another challenge to the system came from the heightened sensitivity of many during the 1960s and 1970s to social injustices. For most of their history, the land-grant complex and the USDA were more responsive to agriculture's haves than to its have-nots. That fact was starkly highlighted by Jim Hightower's 1973 polemic, *Hard Tomatoes, Hard Times*, which damned the land-grant system for betraying small farmers, laborers, and consumers in the interests of large farmers and agribusiness. Sympathetic interest in the underclass has not endured in the United States, but beginning in the late seventies, many family farmers cast a critical eye at the research system. Caught with high debts in a time of declining prices, and squeezed in a narrowing cost-price gap, farmers joined a variety of emergency groups, most notably the American Agriculture Movement. Angry and desperate farmers pointed at many culprits, and prominent among them was a research system that had urged them to do things that drove up their costs, and that had maintained close ties with what they saw as oppressive agribusiness firms. Farmers, especially economically marginal ones, remain critical of the research system in most agricultural states today. (For the interest group environment in which the system now operates, see Browne [1988]).

Added to these external assaults on the system were internal criticisms. Prestigious bodies such as the National Research Council (1972) and the Office of Technology Assessment (1981) issued reports ripping the system for backward and pedestrian research, insufficient coordination and planning, an overemphasis on applied research, and inattentiveness to the social and environmental consequences of research. Such criticisms were painful, because they were reminiscent of the earlier jibes of elite scientists and because they threatened tangible damage if they led to alterations in funding formulas. Moreover, they have been built on by critics within the land-grant complex, especially those who call for an increased commitment to biotechnological research and social scientists who demand a more central role for their disciplines in the system (MacDonald, 1989; Johnson and Bonnen, 1991).

Comfortable and complacent in their island empire, spokesmen for the research system did not receive external and internal criticism with good grace. Their responses combined incredulity and bitterness. These were good people who believed they were serving society, and they reacted with outraged innocence. That attitude now has largely passed away, at least among prominent people in the system. They recognize that today's environment is one of intense public scrutiny and a wide range of public demands. The question they confront is whether the system can be repositioned to function effectively and usefully in this new environment.

Toward a New Equilibrium

Most people who think deeply about the agricultural research system today recognize the need to develop a new equilibrium between the public and scientific sides of the enterprise. In a volatile political world of insistent public and private interest groups, and a scientific world in which new paradigms challenge the old, stasis is not a satisfactory option. Indeed, we may underemphasize the change already taking place, as research institutions strive to meet myriad external and internal demands (Buttel and Busch, 1988).

Developing a new equilibrium is much more difficult today than it was a century ago, when agricultural research institutions initially sought to define themselves. A hundred years ago, and for most of the period since, there was a consensus in the intelligent, educated public that science was a valuable and positive force in society. That consensus no longer exists. It has disappeared in part because science

has failed to deliver all that has been expected of it, but mainly because our society no longer agrees on such broad issues as what is valuable, where we would like to be, or even where we want to go. The value of science, once taken for granted, is now an open question in a society in which some intelligent people see scientists as sorcerers' apprentices, and scientific curiosity as a threat to the well-being of people and nature.

Another related complication in trying to build a new equilibrium are the social attitudes that challenge the very legitimacy of publicly sponsored agricultural research. Many people question whether government should do anything at all that might be done by private enterprise. That attitude, along with the growing state and national budget crises, is reflected in dwindling resources. The research system once benefitted from the social inclination to make public investments in the present to achieve gains in the future, but increasingly we seem to live for today, to think in the short term, and to defer our problems to later generations. Louis XIV's supposed motto, "après mois, le déluge," could well apply to contemporary America.

A century ago, because few people were much interested in it, the research system was free to define, cultivate, and even create its own supportive client groups, but that probably no longer is possible. Farmers, the most dependable clients of the system, are a diminishing minority that increasingly is divided and restive. Agribusiness retains substantial leverage over the system in an era of shrinking public resources, but it presses the system to do the sort of research that will fail to attract a larger public, and even may alienate it. Further complicating the search for a constituency is the fact that although the public generally is not interested in what the system might do, more small single-issue groups are becoming intensely interested. These groups often have conflicting demands that diverge so strongly that they probably are not resolvable. For example, the two groups most interested in animal science today are probably livestock producers and animal rights advocates, between whom common ground is hard to find.

Restructuring the scientific side of the equilibrium is intimately related to the public environment in which research institutions function, as has always been true. Emerging areas of scientific interest quickly become ideological battlegrounds, showing that the ideal of disinterested investigators freely following where their curiosity leads is further from reality today than ever before. Biotechnology and LISA both have committed partisans driven as much by ideology and social vision as by an objective appraisal of scientific possibilities. At the same time, the response to the National Research Initiative, like the historical response to other alterations in funding, demonstrates that the system retains a degree of flexibility and openness to new ideas and approaches.

Scientific restructuring also is complicated by the fact that the disciplines in agricultural science are now mature and have established reward structures. Scientists have an intellectual and emotional interest in the continuing dominance of established paradigms. They are skeptical of new areas of research and new ways of looking at things, and their skepticism is reflected in decisions on promotion, tenure, and compensation. With an academic rather than a corporate model as their guide, public research facilities do not and cannot shift quickly and easily. The result is that a new area such as LISA has a difficult time gaining acceptance from such established areas as agronomy, weed science, and soil science. LISA investigators have difficulty getting published in established journals, which adds to their difficulty in getting tenure. One solution is the creation of separate departments and more specialized journals, and the development of supportive client groups. That was the pattern followed by the older disciplines, but a drawback is that it contributes to the balkanization of the system and an artificially narrow view of the world.

As the publicly supported agricultural research system attempts to achieve a new equilibrium in this difficult environment, it enjoys two big advantages. First, the system has demonstrated historically how adaptable it is, both to public demands and to the shifting tides of science. It is demonstrating its adaptability even now, and presumably will continue to do so. Second, a commitment to service is at the heart of the system's purpose. The genuine desire of many people in the system to serve the public will benefit it as it attempts to achieve a new equilibrium. Whether it will serve the system well enough in this difficult public and scientific environment remains an open question.

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UPCOMING EVENTS

January 20-23, 1993, "Acting on the Challenges for Sustainable Agriculture," the 13th Annual Ecological Farming Conference, will be held in Pacific Grove, CA; contact: Committee for Sustainable Agriculture, P.O. Box 1300, Colfax, CA 95713; (916)346-2777.

January 25-29, 1993, "Soils and Society: Responsible Management" will be held at North Carolina State University, Raleigh, N.C.; contact: TropSoils Management Entity, Box 7113 Daniels Hall, North Carolina State University, Raleigh, N.C. 27695-7113; (919)515-3922.

January 25-27 (St. Charles), February 15-17 (Wabasha), and March 3-5 (Montevideo), 1993, "Farming for Profit, Land and Family," programs sponsored by the Land Stewardship Program, will be held in Minnesota; contact LSP in Lewiston, (507)523-3366.

January 28-30, 1993, National Farmers' Direct Marketing Conference will be held in Portland, OR; contact Vance Corum, 441 Merritt Ave., #104, Oakland, CA 94610-5152; (510)465-8714.

January 28-30, 1993, "Sustainable Farming and the Environment," an international workshop, will be held in Cochin, Southern India; contact United Planters Association of Southern India, R&D Center for Rubber, Union Club Road, Kottayam 686001, Kerala, South India; phone: (0481) 61588, 61579.

January 29-31, 1993, "From Centralization to Diversity," the Winter Conference of the Northern Plains Sustainable Agriculture Society, will be held at Jamestown, N.D.; contact: NPSAS, Box 36, Maida, N.D. 58255; (701)256-2424.

February 1, 1993, is the deadline for abstracts for the Fourth National Pesticide Conference, "New Directions in Pesticide Research, Development, Management, and Policy," in Richmond, VA, November 1-3, 1993; submit abstracts of 300-500 words to Dr. Diana L. Weigmann, Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 617 North Main St., Blacksburg, VA 24060-3397; (703)231-5624.

February 6-8, 1993, "Virginia Direct Marketing Annual Conference and Exhibition" will be held in Colonial Williamsburg, VA; contact Nancy Israel, Farmers Direct Marketing Association, Virginia Department of Agriculture and Consumer Services, 1100 Bank St., 10th floor, Richmond, VA 23219; (804)371-6157.

February 18-19, 1993, "Seventh Annual Virginia Conference on Sustainable Agriculture" will be held in Charlottesville, VA; contact: Conference Registrar, Division of Continuing Education, Donaldson Brown Center, VPI & SU, Blacksburg, VA 24061-0104; (703)231-5182.

February 20, 1993, "A Conference on Sustaining Agriculture Opportunities," the 5th Annual Transitions Conference, will be held at SUNY New Paltz, N.Y.; contact Bob Dibble, SCS, (914)677-3194.

February 21-24, 1993, "Agricultural Research to Protect Water Quality," sponsored by the Management Systems Evaluation Area Program and the Soil and Water Conservation Society, will be held in Minneapolis, MN; contact: SWCS, 7515 Northeast Ankeny Road, Ankeny, IA 50021-9764; 1-800-THE-SOIL.

March 1, 1993, "Alternative Agriculture Policy: A New Time to Choose," the 10th annual conference of the Institute for Alternative Agriculture, will be held in Washington, D.C.; contact the IAA, 9200 Edmonston Road, #117, Greenbelt, MD 20770; (301)441-8777.

EPA Sets Rules to Protect Farm Workers from Pesticides

The EPA has issued rules requiring agricultural employers to protect farm workers from exposure to dangerous pesticides. The rules, which apply to anyone who handles pesticides on farms or in nurseries, forests, or greenhouses, require employers to train workers in the handling of pesticides and the wearing of protective clothing, and to post risk warnings.

Re-integrating agricultural research

Jill Shore Auburn and Brian P. Baker

Abstract. *Interaction between farmers and researchers has benefits for both groups. Researchers gain an understanding of farmers' needs and the production system into which new techniques must fit; farmers are helped in adopting new techniques, and get insights into why some techniques are more successful than others. However, communication between farmers and researchers usually has been just from the university to the farmer. The recovery of information from farmers, integration of techniques into whole production systems, and the research priorities of farmers have not been very important to researchers.*

An exception has been in sustainable agriculture, where some researchers have been asking farmers what they are doing and what they want the university to do, and spending time observing existing practices before they design research trials. Ideally, farmers and researchers interact as equals, sharing information and expertise. We present examples from California and New York that show that this approach is highly effective, and recommend policies to expand on this approach in research funding, training of research and extension personnel, and the dissemination of information. We also discuss practical ways to carry out those policies, drawn from the experiences of both university and private non-profit organizations.

Key words: farmer-researcher cooperation, advisory committees, on-farm research, extension, sustainable agriculture

Introduction

Farmers have long been ambivalent about the Land Grant University (LGU) system. Although proponents emphasize the benefits of LGU research to farmers, often overlooked are the costs and structural disruptions caused by changing technology (Hightower, 1973; Friedland et al., 1981). Criticism of the LGU system has not been limited to the organic agriculture movement, nor is it a recent phenomenon. Frontier farmers at the time of the Morrill Act, and the populist movement at the turn of the century, feared that the LGU system would serve Eastern banks and land speculators at the expense of farmers (Gates, 1960). The results of LGU research created what has been characterized as a "technology treadmill" (Cochrane, 1979). As the system evolved, the economy became less dependent on agriculture, the population changed, and farmers became displaced as the main clientele for public research. Commodity groups, agrichemical companies and now the biotechnology industry dominate LGU research priorities (Busch and Lacy, 1983; Kenney, 1986; Kloppenburg, 1988), and public universities have come under greater pressure to serve commercial needs. The recent fiscal crisis in many LGUs has exacerbated the tendency to allow outside money to dictate research priorities.

At the same time, a small but growing number of researchers have become interested in organic and sustainable agriculture. They have had a greater tendency to work more closely with farmers for several reasons. First, many organic farmers have scientific training and a respect for intellectuals. Baker and Smith (1987) found that organic farmers in New York State tended to be younger and better-educated than the general farming population. The National Research Council (1989) found that both large and small organic farmers were willing to adopt new technologies that they considered sustainable.

Second, organic and sustainable agriculture require a systems-oriented approach. The complex interactions of the system do not lend themselves to standard experiments with reductionist methods. Since farmers must integrate information from various disciplines to farm successfully, their knowledge has been valued more highly by faculty members and students who see an intellectual challenge in the ecological and structural problems that face agriculture.

Third, there is a history of individuals and organizations outside the LGUs delivering information on alternative farming methods and issues. This history may be due in part to the neglect of alternative agriculture by the LGUs, combined with the interests of their students, who then found employment outside LGUs. At Cornell University, for example, an interdisciplinary group of graduate students organized the Ecological Agriculture Research Collective. The group emphasized trials for practical farming systems rather than publishable research. On-farm research was developed interactively with farmers. Information gathered from the research was disseminated by presentations at conferences with a farming audience, rather than published in refereed journals. Although a few members of this group went on to live "normal" academic lives, several (including one of the authors) went to work for non-profit organizations such as Cali-

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fornia Certified Organic Farmers (CCOF), the Rodale Institute, the Land Institute, and the New Alchemy Institute. The Student Experimental Farm at the University of California at Davis has had a similar history of farmer-oriented results that often are unpublished. It was started by students as a way to get practical farming experience besides academic training. This need was expressed by Thornley (1990, p. 176): "To some extent, farmers are almost always researchers, however much they lack scientific rigor. But it is not uncommon to find researchers who have never worked on a farm. We need to require that researchers get some practical experience as part of their educational program. Likewise, we need to promote farmers' knowledge of research design and techniques."

Most importantly, organic farmers are far ahead of researchers in understanding how to farm in cooperation with nature. Organic farmers have performed their own on-farm research, to an even greater extent than most farmers, because the LGU has failed to serve their needs. They have been innovators by expensive trial and error. Scientists in their own disjointed disciplines are only now beginning to validate some observations of organic farmers, such as the observation that plants grown in a well-aerated soil with slowly released balanced nutrients may be less subject to disease and insect pressure than plants grown with highly soluble sources of nutrients, particularly if there is excessive nitrogen (Dale, 1988).

For these reasons, sustainable agriculture is ahead of other areas in recognizing the benefits and constraints of farmer-researcher partnerships and in attempting to reintegrate the two perspectives in various ways (Bunch, 1990; Lockeretz and Anderson, 1990; Thornley, 1990). Successes and failures in these attempts will be instructive if the broader research community moves toward greater interaction with farmers.

Farmers can help to inform agricultural research in three ways: as objects of research, as advisers to research, and as full partners in control of research. The best approach depends on the problem being studied, the circumstances, and the personalities of the researchers and farmers involved.

Farmers as Objects of Research

Most applied agricultural researchers use a limited set of scientific tools for studying phenomena that take place in station plots or in farmers' fields. Alternative agriculture has been more open to methods from the social sciences, such as surveys of farmers' practices and research needs. These surveys can be most helpful in acquainting researchers with farming practices and issues. For example, Baker et al. (1991) took advantage of the information already collected from California growers for organic certification, and organized it into a database for analysis. They compiled data from 476 farms in 1989, including specific management practices and materials used, and their objectives, such as pest management and soil fertility. This database can provide researchers with information on specific practices such as soil amendments (Figure 1) and sources of manures (Figure 2) for the entire group as in these figures or by specific crop. The size and value of the database are increasing; its acreage of fruit, nut and vegetable crops more than doubled from 1989 to 1990 (Figure 3).

Besides formal surveys, farmers' practices and concerns are being gauged in a less quantitative, more exploratory manner through informal interviews and "focus groups" (facilitated small group discussions). These activities often provide background information for a project; they may not be published by themselves, since they are often viewed as unscientific. The University of California's Agricultural Issues Center has used focus groups extensively, for example, in its study of chemicals and food safety (Carter and Nuckton, eds., 1988). Both informal interviews and the scientific literature are used by UC SAREP in its data bases and publications (Auburn, 1991). The Rapid Rural Appraisal (Conway, 1990) and other participatory approaches more common in Third World agriculture are being used in California's Central Valley by at least one UC agricultural researcher (Jeff Dlott, Entomology Dept., Univ. of California, Berkeley, personal communication). An interesting hy-

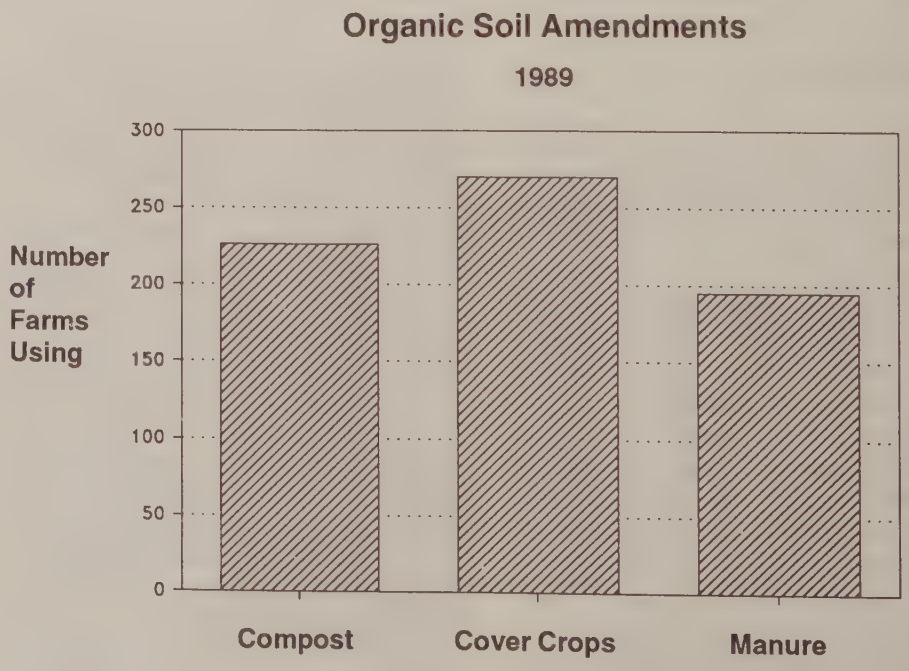

Figure 1. Types of organic soil amendments reported by farmers to California Certified Organic Farmers as part of grower practices database (Baker et al., 1991).

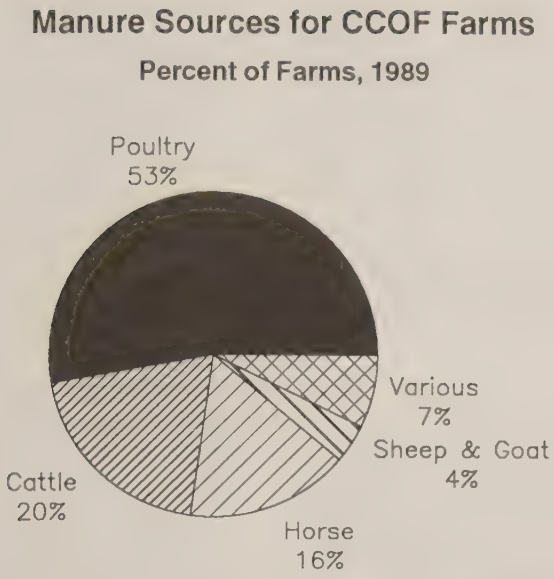

Figure 2. Sources of manure reported by farmers to California Certified Organic Farmers as part of grower practices database (Baker et al., 1991).

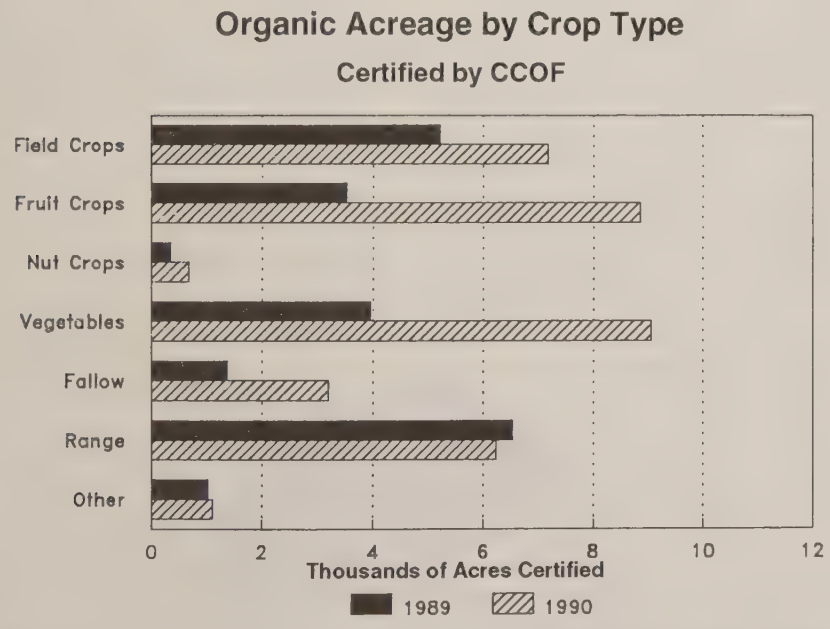

Figure 3. Increase in acreage certified organic by California Certified Organic Farmers, 1989 to 1990 (Baker et al., 1991).

brid uses a survey followed by group discussion and writing (Stabinsky, 1991; Stabinsky and Bolin, 1990).

In field work, too, agricultural researchers can benefit by acting as observers of existing patterns, instead of manipulators of treatments. For example, UC SAREP awards small grants, in the category "Monitoring Innovative Producers," for projects that observe and document alternative systems as they are currently practiced, rather than manipulating treatments and observing their effects. One such project compares several almond orchards that differ in their groundcovers and pest management practices (Hendricks, 1991). This project has stimulated interest among researchers and the almond industry, but has also been criticized for being based on unreplicated comparisons of whole farms. The reason for funding this type of project was that it could quickly and cheaply collect information that would help researchers decide which treatments to include in replicated comparisons. More recently, we have become interested in statistical methods that quantify spatial patterns in farmers' fields (spatial statistics, or geostatistics), allowing conclusions to be drawn about the relationships among key variables without imposing discrete treatments (Nielsen et al., 1983). These methods may allow us to document the long-term effects of management practices without the expense and delay of managing treatment plots for years, and to describe the characteristics of "healthy" systems rather than focus on treatments to cure problems.

Graduate and undergraduate students, particularly in production-oriented disciplines such as agronomy and horticulture, should be trained to appreciate and use a much wider array of scientific and statistical tools and approaches, if we are to use our declining agricultural research money more effectively. The conventional "aggie statistics" (Nielsen et al., 1983), where one or a few treatments are replicated in various blocked designs, have been very successful for studying the effects of specific inputs, such as fertilizers and herbicides, but have limited use for studying more complex systems. Agricultural students should be exposed to methods from ecology and natural history, and from the social sciences, such as surveys, case studies, decision cases (Crookston, 1991), and "quasi-experiments" (Cook and Campbell, 1979). Survey results and experimental treatments can provide complementary information, thus improving the researcher's ability to judge how widely the experimental results apply (Mason et al., 1991). Alternative agriculture often is dismissed as unscientific, which is sometimes true, but too often the criticism stems from a very narrow view of science and of legitimate scientific methods.

Farmers as Advisers

Farmers cooperate in field-oriented agricultural research, although often pas-

sively. Competitive grant programs in sustainable agriculture have stressed farmer involvement, at least as advisers, in both state programs such as UC SAREP and in federal programs such as the U.S. Department of Agriculture's Sustainable Agriculture Research and Education program (SARE, formerly LISA). The SARE model, which emphasizes diverse review committees, interdisciplinary projects, and meaningful farmer involvement "has always been an ideal, but seldom has it been fulfilled" (Miller, 1990, p. 151).

An obstacle to fulfilling the ideal of having farmers participate actively may be that they are assigned too narrow a role as advisers. Farmer and other public input into UC SAREP is specified in the enabling legislation for the program (California State Senate Bill 872 [N. Petris], 1986) as consisting of a public Program Advisory Committee (PAC) of farmers and other members of the public knowledgeable about farming, and a Technical Advisory Committee (TAC, composed of UC faculty, specialists and farm advisers). The legislation specifies the role of the PAC as "recommending goals and priorities for this program, including, but not limited to, reviewing the priority of grant applications," and gives the TAC the narrower role of "making recommendations about the scientific merit of grant applications." In reality, members of the PAC have opinions regarding scientific merit, and members of the TAC have opinions regarding goals and priorities of the program. Therefore, the roles of the two groups are not so neatly distinguished; over the five-year history of UC SAREP, the PAC and TAC have become more like each other. Treating public advisers and technical advisers similarly does not ensure that they will interact as equal colleagues, however. To encourage interaction and to increase common ground among members of the two groups, UC SAREP sponsored a tour of PAC members' farms for TAC members and other university researchers and officials.

Serving in an advisory capacity without decision-making authority can be frustrating. In the words of a former UC SAREP PAC member, "my advice can be followed or ignored at the sole discretion of those with decision-making power" (Thornley, 1990, p. 175). Providing advice also comes at a financial cost, since most farmers and other public advisers to programs like UC SAREP lose income when they are reviewing proposals and attending meetings, and therefore not farming or marketing. Their university counterparts, in contrast, receive their normal salaries on those days. The national SARE program and UC SAREP pay only the expenses of farmer advisers, but a similar sustainable agriculture program in Wisconsin also gives them an honorarium (Stevenson and Klemme, 1992).

Farmers in Control

Practical Farmers of Iowa is among the best examples of farmer-led research that is credible to both researchers and farmers (Thompson and Thompson, 1990). Both UC SAREP and the national SARE program allow farmers and others affiliated with non-profit institutions outside the traditional research system to compete for research and education grant funding. UC SAREP encourages farmers and researchers to work together as partners. In the first three years of UC SAREP funding (Sustainable Agriculture Research and Education Program, 1990), six projects out of fifty-one were awarded to non-university principal investigators with little university involvement (Table 1). Of the six, only one ("Encouraging Profiles") includes on-farm trials or observations; the others compile, analyze and package existing information. Non-profit organizations have been much more eager to apply for UC SAREP's information grants than have LGU researchers or Cooperative Extension specialists.

Farmers and other individuals not affiliated with universities are at a disadvantage in proposing and executing research and educational projects. Their credibility as researchers may be questioned because of real or perceived lack of training or experience. Even if their proposed research is credible, they usually do not have comparable resources for preparing proposals and executing research, such as support staff, salaries, and overhead. Farmers often are advised to keep their experiments simple (Rzewnicki et al., 1988; Thompson and Thompson, n.d.) so that

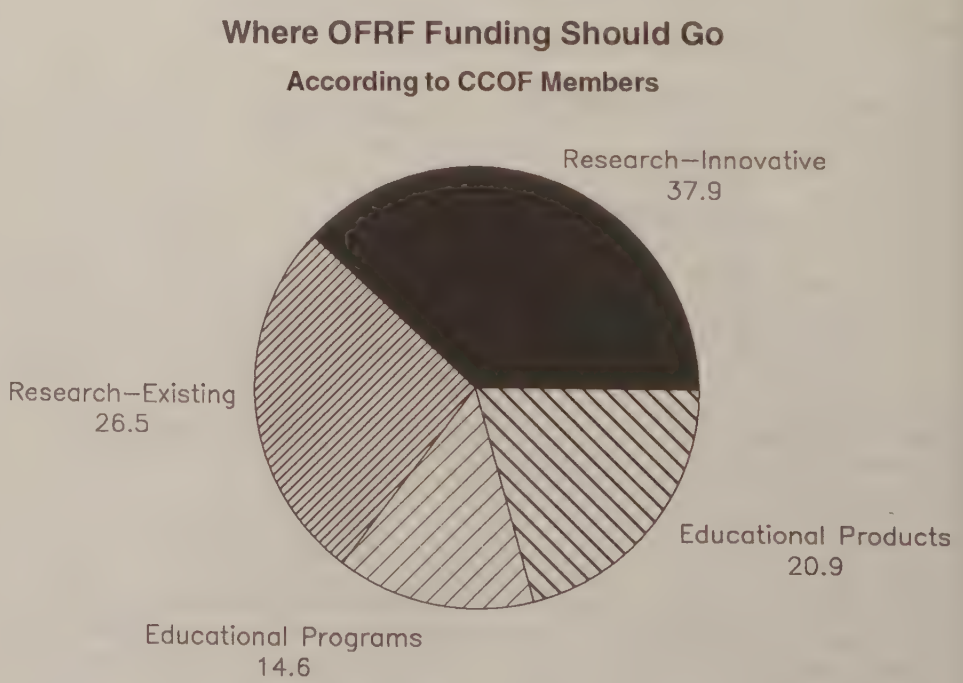

Figure 4. Recommended uses for Organic Farming Research Foundation funds according to a survey of California organic farmers (from Organic Farming Research Foundation, Santa Cruz, California).

data collection and analysis will be manageable, but simple research designs rarely answer important questions about how whole systems perform. Finally, although farmers often are better than traditional scientists at disseminating useful information to farmers, they have fewer incentives and means to publish or otherwise ensure that their research is accessible to others.

As the agricultural experiment stations have become more remote from farmers, experimental data not validated on farms is received with skepticism. Most organic farmers (Baker and Smith, 1987) and probably also many conventional farmers view the results of on-farm research as more credible than research from experiment stations. Not only are the conditions of a controlled experiment different from those faced by farmers, but also the objectives and incentives faced by farmers and researchers often are divergent. Farmers are constrained by the need to produce and market their products. Participation in research must take a back seat to running the farm. Unsubstantiated testimonials may damage the credibility of on-farm trials among researchers, but farmers are wary of experiment station data not filtered through practical experience.

Farmers may be more successful at directing research by controlling research funding. Commodity groups in California have traditionally controlled industry funding of agricultural research, usually in close cooperation with the university. The Organic Farming Research Foundation (OFRF) was formed recently to sponsor research on organic farming and to disseminate information to farmers, policy-makers, and the public. OFRF's bylaws specify a majority of farmers on the board: at least eight certified organic farmers; two researchers; and one consumer representative. Last year, OFRF surveyed organic farmers in California, Oregon and Washington regarding their research and information priorities. Preliminary results from 155 farmers in California (15 percent of those surveyed, all members of CCOF) show they are more interested in research than educational projects, especially research on innovations rather than on existing methods (Figure 4). They also strongly agreed with the statement that OFRF-funded research should "produce useful information that can be applied to farms immediately," (average rating of 4.3 on a scale of 1 to 5), which may be incompatible with risky, innovative approaches. Farmer involvement in design and execution of the research was rated equally highly (4.3), while the "academic credentials and credibility of researchers" and their "track record of interest in organic farming" were rated somewhat less important (3.9 and 3.8, respectively).

Because OFRF is just getting started, it is too soon to compare its operation to university-based programs or to conventional commodity programs. Future comparisons might cover research versus educational emphasis, basic versus applied nature, interdisciplinary versus component scope, and packaging and delivery of the resulting information.

Table 1. Grants from University of California's Sustainable Agriculture Research and Education Program awarded to non-university organizations, 1986-90.

Title	Organization
Organic Farmers' Methods and Practices	California Certified Organic Farmers
Encouraging Profiles	California Clean Growers' Association
Analysis of the Marketplace	Committee for Sustainable Agriculture
Farmer-to-Farmer Field Days	Committee for Sustainable Agriculture
Learning from Sustainable Agriculture in China	Bio-Integral Resource Center
Least-Toxic Pest Management Directory	Bio-Integral Resource Center

Information Networking

Although obstacles such as those mentioned above may prevent farmers from participating as full partners in all forms of research, there are fewer obstacles preventing them from being full partners in exchanging information, and these are declining (Francis et al., 1990).The sustainable agriculture movement has partially escaped the "top down" flow of information from LGU researcher to farmer via extension agent, since farmers, farmer-oriented non-profit organizations, and other non-traditional sources of information have been prominent from the start. Declining extension budgets around the nation also have stimulated interest in networking information from a variety of sources, rather than Extension trying to act alone.

Non-profit organizations have been especially active in promoting farmer-to-farmer communication among individuals and at field days and conferences. Recent examples in California include transition conferences and field days sponsored by the Committee for Sustainable Agriculture, and farm tours sponsored by the Farmers for Alternative Agricultural Research project of the California Action Network and other groups (Stabinsky, 1991). UC SAREP has encouraged cooperation among non-profit organizations and county extension advisers in sponsoring meetings and field days for growers. In some cases the cooperation has worked well; in others, it has not. To succeed, these efforts require longer-range planning and additional coordination time to arrive at agendas that everyone can support. This extra time can be burdensome to all parties, particularly if they are focussed on putting on a good event, rather than building organizational relationships for the longer term.

The sources, users, and types of information relevant to sustainable agriculture are becoming more diverse. The national SARE program recently funded the development of an information network to facilitate the sharing of information on sustainable agriculture among universities, government, non-profit and for-profit businesses, in a variety of traditional and non-traditional forms. One activity of the network committee is to improve the availability and credibility of "experiential" information, defined as information that is based on observations and experiences rather than on experiments. Other activities include a directory of sources of information, handbooks and other new publica-

tions, formats and procedures for sharing information in computerized form, and standardized terminology for describing and accessing information on sustainable agriculture. The network coordinating committee, chaired by one of the authors (Auburn) is committed to the decentralized flow of information among diverse actors, including farmers and other individuals and groups outside the universities.

Implications

Sustainable agriculture has been identified with environmental and social goals: most narrowly, to reduce dependence on synthetic pesticides and fertilizers; more broadly, to remedy the environmental, economic and social ills of the food production and distribution system. In trying to achieve these goals, it also has taken the lead in changing how research and education are done, making them more responsive and relevant to the needs of farmers and society. In particular, sustainable agriculture has increased interaction among researchers, farmers and the public, and increased acceptance and use of a wider range of research methods and a richer web of sources and types of information.

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Congress Completes Hearings on Agriculture and Family Farms

The Joint Economic Committee of the U.S. Congress recently hosted a day-long symposium in Washington, D.C., to complete a series of four hearings on "Agricultural Industrialization and Family Farms: The Role of Federal Policy" (reported in the August issue of **Alternative Agriculture Resources Report**). Committee Vice Chairman Lee H. Hamilton of Indiana, who opened the symposium, said the basic question is "how we can organize our agricultural system to be more competitive, less environmentally damaging, and more rewarding to farm families." He added, "We do not have answers; we may not even have the right questions. But we have heard enough to have become interested."

Dr. Stewart Smith, senior economist for the committee and principal organizer of the hearings, argued in the opening paper that "the development of U.S. agriculture into an increasingly industrialized system has resulted in a substantial shrinkage of the role of farming in that system"—and an expansion of input sector and marketing sector activities. Sustainable agriculture, Smith said, involves more, not less, farming activity. Therefore, the Land Grant university research agenda and current agricultural policies must be redirected to support technologies that will not continue to "shift activity from farmers to nonfarm firms." For details on the hearings, contact Dr. Stewart Smith at (202)224-5171.

Advisory/oversight councils: An alternative approach to farmer/citizen participation in agenda setting at land-grant universities

G. W. Stevenson and Richard M. Klemme

Abstract. *Reviews of historical and organizational literature provide the backdrop for a general discussion of citizen input into land-grant universities and for a specific case study: the Citizens Advisory/Oversight Council of the Center for Integrated Agricultural Systems (CIAS) at the University of Wisconsin-Madison. This strong citizens' council, established in 1989, took its form in response to institutionally structured fears among university personnel, on one hand, and farmers and citizen groups on the other. Each group's recognition that the other's concerns were legitimate led to an acceptable resolution. We describe the principal characteristics of the resulting successful CIAS Council that is composed of farmers and representatives of the state's environmental community. Such councils facilitate new approaches to integrating the craft and science of farming, and for linking the production side of agricultural systems with policy issues.*

Key words: academic freedom, research priorities, land-grant system, the Progressive Era, the "Wisconsin Idea"

Early Conflicts in the Land-Grant System

Current conflicts over the role of land-grant universities and farmer/citizen interactions with these institutions have striking antecedents in the late nineteenth and early twentieth centuries. Citizen input with clear communication between farmer/citizens and the university was among the goals of the land-grant system when it began with the Morrill Act in 1862. During the turn of the century Progressive Era, the "Wisconsin Idea," in which "the boundaries of the University were the boundaries of the state" and "experts were on tap, not on top" demonstrated these principles in ways that drew national praise for the state and its land-grant university (Carstensen, 1956).

A careful reading of history, however, reveals that such institutionalized dialogue in Wisconsin and other states often resulted from political struggles in which farmer organizations and state legislators prevailed upon often reluctant boards of regents and colleges of agriculture to establish educational and research forums that were relevant to the state's farmers and rural population (Carstensen, 1956; Woerdehoff, 1956).

At the base of these contentions was a fundamental disagreement over the nature and mission of the new agricultural colleges established after the Civil War. The farmers' vision for these public institutions was grounded in what might best be described as a *craft-based* understanding of agriculture, now often called experiential or indigenous knowledge. Under the craft formulation of the late 19th century, the important knowledge base for improving agriculture would be derived from "collecting and systematizing" understandings gained from the production and management experiences of the state's most successful farmers, the master craftspeople (Kirkendall, 1986; Marcus, 1986). From this perspective, the main faculty members of the new agricultural colleges should be these master farmers, and the principal student body should be the next generation of farm operators. The new colleges were clearly envisioned as *agricultural business schools*, where high value was placed on students doing practical work. The "college farm" was seen as the key pedagogical tool (Marcus, 1986).

On the other side was a newly emerging group of academic professionals whose vision of the new agricultural colleges was grounded in a *science-based* understanding of agriculture. These new agricultural professionals, who often were the sons of farmers, were struggling to legitimize themselves in the eyes of more established non-agricultural university scientists (Marcus, 1985). Under the formulation of these emerging academics, the important knowledge base for improving agriculture would be derived from scientific methods that would "determine and verify the laws of plant and animal growth" (Marcus, 1988). The concomitants of this vision of agricultural colleges as *institutions of science* were that the faculty should be composed primarily of scientific professionals, and that the principal student body should be future agricultural scientists, not future farmers (Marcus, 1988; Kirkendall,

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1986). Under this vision, the laboratory and the scientific method would replace the college farm and practical work as the educational foci (Marcus, 1986).

Struggles between these two groups' competing visions occurred on several institutional fronts between 1870 and World War I. Farmers' institutes, Chautauqua-like events lasting one to three days that moved around rural areas during the winter, were very popular during the 1870-1880s (Kirkendall, 1986; Marcus, 1986). Winter short courses, which were concentrated three-month sessions conducted for farmers on agricultural college campuses, were established in the 1880s and 1890s. However, these institutes and short courses evolved into a one-way approach to disseminating information, with only college personnel allowed to present lectures. This caused farmers and their institutional allies to resist them, and spurred the development of alternative farmers' institutes (Marcus, 1986).

As indicated above, the nature and form of agricultural research also were a source of contention during this period. Although farmer organizations were not categorically opposed to the contributions of the agricultural scientists, they sought to gain control over agricultural research wherever possible (Marcus, 1988). Station scientists, however, increasingly chafed under farmer-controlled restrictions and pushed for the freedom to investigate more esoteric and scientifically-legitimizing questions (Carstensen, 1956; Marcus, 1988).

As agricultural research evolved from the first publicly funded experiment station that did true research (New York, 1882), through the Hatch Agricultural Experiment Station Act of 1887, the Adams Act of 1906, and the Smith-Lever Act of 1914, control gradually shifted from farmers to scientists, who also became the primary source of information (Marcus, 1988). The farmer-dominated board of control at the New York research station gave way successively to shared control under the Hatch Act, strengthening of the scientists' position under the Adams Act, and greater separation of researchers from farmers with the establishment of an information dissemination system based on the county agent (Marcus, 1988).

The mid-century revolution in American agriculture

Dramatic changes since World War I amounted to what one author has dubbed the "second American agricultural revolution" (Hadwiger, 1982). Key to this transformation was the philosophy that farming is primarily a business rather than the underpinning of a uniquely valuable way of life based on large rural populations of independent, agriculturally based citizens (Kirkendall, 1986). This "farm management" approach coupled powerfully with the science-based perspectives of the university's agricultural professionals to forge a land-grant agenda focusing primarily on new technologies for increasing agricultural production (Kirkendall, 1986).

The twentieth century revolution in agricultural production had important consequences, both expected and unexpected. First, the American farming community was restructured from a relatively homogeneous nationwide occupational group into sub-populations distinguished by region, farm size, products produced and other socioeconomic determinants (Buttel and Busch, 1988; Marcus, 1988). Second, labor-saving and production-enhancing technologies generated a massive migration off the land and out of rural areas (Danbom, 1986; de Janvry and LeVeen, 1986). Third, cycles of overproduction already nascent in the system were accentuated (Buttel and Busch, 1988; de Janvry and LeVeen, 1986; Marcus, 1988). Fourth, the intensive farming practices made possible by the new production technologies caused serious but unanticipated damage to the country's natural resource base (National Research Council, 1989). Finally, U.S. agriculture became increasingly industrialized and internationalized (Cooper, 1986; de Janvry and LeVeen, 1986; Kloppenburg, 1988; Marion et al., 1987; Urban, 1991).

There is considerable debate over the causal relationships and the net gains and losses from the mid-century agricultural revolution, but its ramifications for public input to land-grant universities have been clear. Except for the American Farm Bureau Federation, the influence of general farm organizations declined during this period. Instead, well-organized commodity groups emerged as a leading influence on the land-grant system (McConnell, 1953; Campbell, 1962; Hadwiger, 1982; Marcus, 1988). Agribusiness also became an important source of public input and a partner in research (Buttel et al., 1986; Buttel and Busch, 1988). More recently, environmental groups have become increasingly influential in setting university research agendas (National Research Council, 1989). These shifts have been significant in that land-grant universities now serve diverse interests, many of which are not farm-based and have agendas that reach well beyond rural communities (Buttel and Busch, 1988).

The influence of peer scientists and the widening clientele of the land-grant system have been manifested in the system's increasingly dominant emphasis on enlarging the boundaries of science, expanding overall agricultural production, and general economic growth for the national economy (Danbom, 1986). Given these larger, less farmer-oriented emphases, the system has gone through periods of both strong support and criticism. When agricultural productivity was static and food prices were rising steadily (for example, during the periods 1900-1920, 1940-1960, and 1970-80), university administrators and scientists received considerable public support as they pushed ahead vigorously with their productivity-enhancing and professionally-legitimizing agendas (Danbom, 1986). Cycles of criticism erupted in the 1920s and 1930s and again in the 1960s and 1980s when overproduction and its perceived association with low commodity prices, depressed agricultural incomes, and rural community deterioration emerged as major agricultural and rural problems. Negative attitudes toward the land-grant system were shown most strongly through budget cuts at both the state and federal level (Danbom, 1986).

The most recent wave of criticism has focused on four fronts: the environmental impacts of post World War II agricultural research (Carson, 1962; Danbom, 1986; National Research Council, 1989); who are major beneficiaries of research (Hightower, 1973; Schultz, 1977; Buttel et al., 1986); how land-grant research directions are determined (Berry, 1977; Busch and Lacy, 1983); and the quality of science

emerging from the decentralized, state-based experiment station system (Danbom, 1986).

During the twentieth century, representatives of the land-grant system have consistently responded to these criticisms by vigorously defending the heart of the system while acknowledging the critiques by adding broader perspectives on the periphery (Rosenberg, 1977; Danbom, 1986). For instance, Henry A. Wallace, Secretary of Agriculture during the first two Roosevelt Administrations, had little patience for those who argued that overproduction raised serious questions about research agendas. However, he also recognized the shortcomings of a science that did not consider larger social goals, and was instrumental in expanding the role of agricultural economics, rural sociology, and home economics within the USDA and the state experiment stations (Danbom, 1986).

Like Secretary Wallace in the 1930s, recent land-grant authorities have responded to the criticisms of the past twenty-five years primarily by acknowledging their merits and then turning to shore up and reform the system's production and science-oriented core (Danbom, 1986). A series of national reports in the 1970s and 1980s, for instance, all began by acknowledging that the land-grant system placed low priority on issues like environmental degradation, nutrition, and socioeconomic externalities, but quickly concentrated on the system from a scientific point of view (National Research Council, 1972; 1975; Office of Technology Assessment, 1981). Such deflective responses to public concerns, although not the sole cause of declining support for public research, clearly raise the issues of accountability and public input within land-grant universities.

The Wisconsin Experience

The struggles over the role of the college of agriculture and the interaction between farmers and the University of Wisconsin were similar to the national patterns described above, but had some unique features. The greatest difference was that the University of Wisconsin was significantly more responsive to the protests and concerns of the state's farmer citizens than most land-grant institutions, and before World War I had developed several programs that became models for the nation (Glover, 1952; Carstensen, 1956).

Such responsiveness was the result of several political and cultural forces. First was the strong belief, shared by the political leadership in many midwestern states during the mid-nineteenth century, that public universities should primarily be utilitarian institutions addressing "the popular needs of farmers, mechanics, miners, merchants, teachers, and other citizens" (Carstensen, 1956). The second force, which was more specific to the state, was expressed through the political ascendancy of the Progressive Republican Party in the late 19th and early 20th centuries under the leadership of Robert M. LaFollette, Sr. The "Wisconsin Idea" was articulated through the intellectual and political collaboration of close associates of LaFollette and a series of sympathetic University presidents from the early 1880s through the early 1910s (Carstensen, 1956; Haveman and Shroder, 1989).

Although the University of Wisconsin was a responsive and creative institution, the impetus for nearly every model program established during this period came from outside the University. Winter "short courses" for farmers, inaugurated at the University of Wisconsin in 1886, were the direct outcome of threats made in 1885 by several of the state's farmer organizations to separate the agricultural college from the University (Carstensen, 1956). In 1887, the state legislature convened a series of one-to-three day farmers' institutes that "gave the professors a chance to talk to farmers and, what was perhaps more important, gave the farmers a chance to talk back" (Carstensen, 1956). Several observers later credited the institutes with a pivotal role in transforming the state's agriculture from a dependence on monocropped wheat to more diversified farming systems, often with an emphasis on dairying (Carstensen, 1956). The success of the short course and farmers' institutes in the 1880s and 1890s provided the rationale for greatly expanding university Extension programs during the first two decades of the 20th century.

As with the earlier institutional innovations in Wisconsin, the impetus for these groundbreaking Extension activities came from outside the University. The creative power of citizen/university interaction that features concerned insistent people and responsive institutional leaders is shown by how many ideas developed in Wisconsin during the Progressive Era were used by land-grant institutions in other states after the Smith-Lever Act was enacted in 1914 (Carstensen, 1956; Woerdehoff, 1956).

However, much of the energy behind these institutional initiatives was drained after World War I, when the Progressive party was seriously split, both nationally and statewide (Carstensen, 1956). Despite lip service to farmer/citizen input, the institutionalized dialogue that the Wisconsin Progressives had in mind atrophied still further over the next two generations. It was during these next seventy years that American agriculture changed most dramatically, first with major production increases and then with the environmental and socioeconomic concerns that characterized the previous discussion.

Responsiveness and adaptability as strategies for institutional survival have been integral characteristics of the land-grant system since the 1870s (Danbom, 1986). In the current cycle of dissent, it is increasingly clear that public research institutions are beginning to hear and respond to the voices of both external and internal critics. Courses and research centers focusing on the farm-level environmental issues of integrated pest management and sustainable agriculture have emerged in many land-grant universities over the past decade.

It has been more difficult for the system to meet the challenge of dealing seriously with the larger socioeconomic consequences of technological innovation and production-oriented research. Yet even on this sensitive front, some understanding and responsiveness have emerged. Defining the first mission of land-grant institutions as "the development of the physical agricultural sciences and the creation of new production technologies," a voice well established within the land-grant system has proposed a second, complementary land-grant mission, one that "seeks to cope with the social, economic and institutional problems of rural people" (Cochrane, 1979). Voices like these give hope to those who encourage and expect the land-grant system to work toward the com-

plementary goals of a highly productive agriculture and vibrant, diversified rural societies.

The Center for Integrated Agricultural Systems at the University of Wisconsin—Madison

Accompanying the most recent wave of criticism has been a growing demand from farmers, environmentalists, and rural advocacy groups for significant input into the agendas of public university programs, a call for renewing the original land-grant commitment to communication. Too often advisory committees picked by the university have been entertained semiannually on campus and seen primarily as institutional supporters rather than sources of critical input for institutional planning. Increasingly groups from California to Vermont, Minnesota to Texas have been challenging colleges of agriculture to rethink their research, extension, and curriculum agendas and to reinvolve farmers and rural citizens in the process (Jaschik, 1991).

The Center for Integrated Agricultural Systems (CIAS) at the University of Wisconsin-Madison resulted from two developments: the most recent wave of farmer/citizen politicization, and the responsiveness of a land-grant university that increasingly recognizes the need to complement traditional and disciplinary research with more interdisciplinary approaches that take seriously both the production and socioeconomic dimensions of contemporary agricultural systems.

The CIAS was established in the School of Natural Resources of the College of Agricultural and Life Sciences (CALS) at the UW-Madison in 1989. Its creation followed eighteen months of evaluation and planning by a College committee chaired by a senior faculty member experienced in farming systems research. Given that discretionary budgets within the College were severely constrained, the initial funding proposed for the Center was low. A coalition of farm and environmental organizations concerned about sustainable agriculture and water quality issues began a dialogue with University faculty and generated a successful lobbying effort to secure additional funding through the Wisconsin Legislature.

In return, the coalition negotiated with the University to establish an eleven-member farmer/citizen Advisory/Oversight Council for the CIAS. Two Council seats were designated for representatives from the environmental community, and at least half the members were to be farmers with "demonstrated experience and leadership in low-chemical agriculture." As its name implies, the Council's purpose is twofold. In its advisory capacity, it provides citizen input to the Center's research and educational/informational programs. In its oversight capacity, it reports annually to the Governor and Legislature with "an independent assessment of the [Center's] activities."

The Council advises and oversees several program areas within the CIAS. At the Center's founding, these areas included a Nutrient and Pest Management program connected to Extension, a curriculum development program in conjunction with the state's Department of Public Instruction and the Wisconsin Rural Development Center, and a research initiative program. As the Center's major focus, the research program is designed to encourage agriculturally oriented, interdisciplinary research within the University of Wisconsin System. In 1990, a fourth programmatic component was added to the CIAS through additional legislation. The goal of the Agricultural Technology and Family Farm Institute is to evaluate the socioeconomic impacts of new technologies on family farming and rural social structure.

The formative period: Background fears

It became clear very early that there were two camps concerned about the Council's potential direction and eventual operating style, particularly regarding the institutional power and influence the Council would have in the research scientists' community. One camp, composed primarily of some university faculty and administrators, feared that the Council would evolve into a board of directors. Questions regarding institutional authority focused on the concern that the Council would "micromanage" the CIAS programs and use its power to infringe on scientists' academic freedom.

The other camp, composed primarily of some farm/rural advocacy groups and state legislators, feared that the Council would evolve into a board of visitors. These people mainly were worried that the Council would be transformed into a "rubber stamp committee" that would meet infrequently and ritualistically, seldom be brought in at the start of policy decisions, and in general not be taken seriously.

Resolving the fears: Theoretical and experiential sources of an alternative approach

These highly contentious fears promised to immobilize the Center. Key supporters from both camps began exploring some way to resolve them. The first and fundamental stage of resolution was for each camp to recognize that the other's concerns were legitimate.

In the second stage, all parties (particularly the Council members, Center staff, and University administrators) explored other visions and approaches that would move the focus from a win/lose battle for institutional influence to the win/win potential of a strong advisory/oversight relationship between a citizens' group and the University. These explorations were guided by important social science organizational analyses of university-stakeholder partnerships (Miller et al., 1990), by new private sector emphases on team communication and sensitivity to customer or client preferences (Deming, 1982; Kanter, 1983; Peters and Waterman, 1982), and by "farmer first" approaches used in the Third World (Chambers et al., 1989).

Beside the understanding provided by these organizational analysts, important characteristics of the CIAS model for citizen input were generated from the experiences and insights of Council members, Center staff, University faculty and administrators committed to the Center's successful development. The nine farmer members of the Council all are experienced in agribusiness, and were selected to represent the diversity of Wisconsin agri-

culture rather than commodity organizations. This significantly reduced the chances of interorganizational rivalries interfering with Council deliberations. The other two Council members are well-respected members of the environmental community with extensive experience in alternative organizational structures.

An experienced group of faculty members and appropriate College administrators began a dialogue with the Council. Important to the successful outcome of these dialogues was that all parties were genuinely committed to revitalizing the state's agriculture and rural life.

Frequent meetings emphasizing a strong interactive format were held during the Center's formative period (twelve meetings over eighteen months). The frequency of these meetings and the high caliber of the people resulted in several important outcomes. First, Council members became well acquainted, leading to a relaxed meeting atmosphere and an openness to other opinions. Second, a freshness and continuity of ideas carried over from meetings, allowing Council members to act as partners with Center staff. Finally, members of the Council, the faculty, and the administration become more comfortable about taking a chance on a new approach. The principal characteristics of the CIAS model discussed below emerged from the candid dialogue of these frequent meetings.

CIAS Model Characteristic #1: Council members recognize the administrative authority of the University and the academic freedom of its faculty.

The Council clearly is an advisory group, not a governing body. This means that it provides input primarily on general policy priorities and program directives, leaving final authority and day-to-day decisions to the Center director and staff. This characteristic recognizes the legitimate concern among the faculty and administration that the Council not assume the "micro-management" role of many boards of directors. The Council benefits from this understanding because it does not shoulder any legal responsibilities for the consequences of the Center's program.

An example of how this works in practice is seen in the operation of the CIAS research program. A competitive grant process, followed during the Center's first two funding cycles, has been directed by a balance of citizen and scientist input. The overall guidelines for the call for proposals were recommended by the citizens' Council following discussions with faculty and the Center's staff. The guidelines for these initial calls emphasized interdisciplinary approaches with substantial farmer/citizen involvement that address farming or rural systems in holistic ways.[1]

Each proposal is reviewed and rated on its technical merit by two scientists and the CIAS director. Abstracts of the proposals are reviewed by Council members and rated on the degree to which they meet the guidelines. Council members meet with Center staff and selected scientists to generate an overall evaluation of each proposal. Based on these evaluations, the Council forwards funding recommendations to the CIAS director, who makes the final decision.

CIAS Model Characteristic #2: The Center's staff treats public input as an integral part of its decision-making process.

In its advisory functions, the Council is viewed as a full partner with the University's faculty and administration. This sends a clear message that public input, even if it is highly critical, is viewed as a valuable contribution to the Center's planning and decision making processes. This characteristic recognizes the legitimacy of the concerns of citizens' groups and legislators that the Council not be transformed into an innocuous board of visitors.

Examples come again from the CIAS research program. After evaluating the Center's first two funding cycles, Council members made known their strong concern that the competitive grant process was seriously deficient in eliciting proposals dealing with agricultural and rural policy issues, as opposed to cropping and other production issues, and that far too many funded projects were not truly interdisciplinary or systems-oriented as described in the research guidelines. Such constructive criticism prompted a series of discussions with the faculty, resulting in a recommendation to fund fewer, larger projects that are more fully interdisciplinary. Also, the Center's staff has been requested to facilitate research teams that will focus on systems-oriented problems at three different levels: on-farm relationships (e.g., interactions between cropping and animal systems); farm/rural community relationships (e.g., types of off-farm employment most supportive of family farm operations); farm/community/state relationships (e.g., transportation systems that foster rural town revitalization or the development of value-added agricultural enterprises).

CIAS Model Characteristic #3: Early input and frequent feedback are the operating principles of staff/council interaction.

The Council's advice is sought early in the Center's planning and decision processes. Feedback from the Center's staff is frequent, and when the Center director disagrees with the Council's advice on a particular issue, a clear effort is made to reach an accommodation. When this is not possible, the Council is told in writing why its advice was not followed. This assures the Council that its input is taken seriously, but also makes it clear that the decision-making authority lies with the Center's director.

Organizational mechanisms to facilitate communication include frequent Council meetings, structured, decision-focused meeting agendas set by Center staff and the Council's executive committee, and streamlined methods for contacting Council members as needed. So far, the Center director has not overruled a major Council recommendation. The dialogue and accommodation processes have successfully handled several minor issues. An issue that potentially could generate significant disagreement with the Council is the director's strong belief that the faculty should be more involved in making final recommendations for research funding.

[1]Copies of the complete guideline contained in the CIAS call for research proposals can be obtained by writing the CIAS, 146A Agriculture Hall, University of Wisconsin, Madison, WI 53706.

CIAS Model Characteristic #4: The Council's oversight authority empowers it to submit an annual report to the Governor and state Legislature evaluating the Center.

This is the complementary authority that balances the University's administrative authority regarding the CIAS. These reports evaluate the Center's programs by several criteria. If the Council believes that its advice is not being taken seriously, it has the responsibility to report that judgement, along with whatever recommendations it deems appropriate, which could include reducing the Center's budget. The annual reports are written by independent authors paid by CIAS but directed by the Council's Executive Committee. Given the input and feedback assurance described above, the evaluations for the Center's first two years have been extremely positive.[2]

CIAS Model Characteristic #5: This highly interactive Council requires the use of innovative organizational mechanisms.

Several organizational mechanisms are used to make Council/staff interactions efficient and not too burdensome to busy farmer/citizens who live around the state. The Council has a four-person executive committee (empowered to make binding decisions between Council meetings) and designated representatives to steering committees associated with the Center's four program areas. A significant portion of Council/staff interaction occurs through these steering committees. Also, resource persons and temporary working groups composed of selected Council, faculty, and administration members are regularly employed.

Group telephone conferences are used extensively, particularly in the summer, to bring together participants spread throughout the state. We have found that once Council members have met face-to-face enough times to generate trust, such telecommunication is very effective. Despite such distance communicating, however, the Council still meets frequently, particularly during the winter. Given this reality, the Center has instituted two important support mechanisms. First, Council members' spouses are encouraged to attend meetings, with their expenses paid. Second, an honorarium is paid to all farmer members who must hire labor to be able to attend Council meetings.

Future challenges

This emerging model has evolved in ways consistent with earlier cited research on effective citizens' input to public institutions. The characteristics listed above have been developed by individuals involved in the Council, the Center, and the University. Maintaining the integrity of this model will require addressing and overcoming the following future challenges. First, the high level of trust between Council and Center staff must be maintained as new farmers and citizens are rotated onto the Council. Second, the creative tension, important to the success thus far, must be maintained by continually seeking institutional critics or those farmer/citizens who do not feel well served by the University's current research, extension, and teaching programs. Finally, gaining wider acceptance of this advisory/oversight model within the College of Agricultural and Life Sciences is essential if the Center and this model are to withstand changes in the Center's staff or in the College's administration.

Conclusion

The CIAS Citizens Council with its advisory and oversight capacities is an innovative contemporary model for significantly involving farmer/citizens in setting the agendas at land-grant universities. The acceptance of this public input by university administrators and the faculty testifies to the considerable responsiveness of the public research system, an institutional quality with historical antecedents reaching back to the late 19th century. Several encouraging outcomes of the substantial interaction between farmer/citizens and university scientists required by this new model are emerging at the University of Wisconsin. They address two pairs of conflicting agricultural dimensions that have haunted the land-grant system since its inception.

The first is a growing potential for resolving the "craft vs. science" conflict over agricultural production systems that goes back to the 1870s. Participants in the farmer and scientist teams that the CIAS organizes and funds increasingly are discovering the complementary resources that both sides bring to their research and educational efforts. For example, experiment station research on new animal grazing technologies benefits significantly from the insights of farmers with years of grazing experience. Concomitantly, farmer explorations into new methods for establishing more productive pastures are strengthened by replication-based research methods provided by university scientists.

Second, citizens on the Council are becoming stronger advocates of an integrative approach to production and socioeconomic or policy questions. Research recommendations emerging from the Council challenge the University's production and social scientists to work together in addressing issues like the socioeconomic and environmental impacts of new agricultural technologies, the applications of basic biological research to state problems, and agricultural contributions to rural development strategies that create well paying jobs and retain greater value on farms and in rural communities. New models for integrating the craft and the science of farming and for linking the production side of agricultural systems with policy issues may be the most significant contribution to emerge from the innovative forms of farmer/university exchange currently being explored at the University of Wisconsin and similarly responsive land-grant universities.

[2]Copies of the Citizens' Council's annual oversight reports to the state legislature are available by writing to the CIAS at the address given in footnote 1.

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Farm Profiles Invited

For its new department on alternative agriculture profiles, the **AJAA** welcomes short articles describing farmers who have adopted interesting alternative practices. The articles should include five elements: a brief description of the farm; the problems that made the farmer look for an alternative approach and the reasons why the alternative seemed plausible; a summary of the basic principles behind the alternative (possibly in a sidebar if it interrupts the flow of text); a discussion of how well the alternative has worked; and a discussion of the applicability of the alternative for other farms. The length should be 1500 to 2000 words.

Submissions must be accompanied by a release, signed by the farmer, giving permission for this material to be published in the **American Journal of Alternative Agriculture**. Vol. 3, No. 4, of the **AJAA** has a further description of the department (page 188); or query the editor for further information. Send submissions to the Editor, **AJAA**, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

Letters To The Editor Invited

The **AJAA** welcomes letters, short or long, commenting on articles in this journal or sharing ideas likely to be of interest to other **AJAA** readers. Since our space is limited, we do reserve the right not to publish all letters or, at times, to publish only excerpts from them. To take part in this exchange of ideas, write to: Editor, **AJAA**, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

Farmer participation in research: A model for adaptive research and education

John M. Gerber

Abstract. *Many farmers view with skepticism the dominant agricultural research and extension education model, in which new knowledge on farming practices is developed by researchers and delivered through extension programs. The participatory research and education model is designed to support a shared vision of research and education as a learning process among partners working in community. The participatory model is offered as a way to achieve better communication and enhanced cooperation among farmers, researchers and extension educators.*

Key words: participatory research, experimental design, extension education

Introduction

New farmer-managed, community-based sustainable agriculture organizations have formed throughout the U.S. in an attempt to develop and share ideas on farming practices that are both profitable in the short-term and sustainable in the long-term. With some notable exceptions, public universities were left on the periphery of this largely farmer-driven activity in its early stages. As the land grant community began to acknowledge the need for research and education focused on long-term agricultural sustainability, a call for new programs came from the disciplines of agronomy, agricultural economics, and agricultural ecology. Some farmers were suspicious of or dissatisfied with programs initiated by land grant institutions (Watkins, 1990). Some researchers called for a new model for agricultural research and education based on a vision of partnership that better accommodates the needs of agricultural producers (Chambers et al., 1989).

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Knowledge can dramatically affect the farmer's ability to compete in global markets and be good stewards of resources. Yet the means for generation of scientific knowledge is largely out of their control, and indigenous knowledge acquired through experience is undervalued by most researchers and many farmers. Both scientific knowledge and indigenous knowledge of local agroecosystems is required for successful implementation of new products or practices. Participatory research and education programs recognize the importance of both kinds of knowledge and provide an institutional framework for interaction among extension educators, researchers, and farmers (Gardner, 1990).

Farmers' and Scientists' Ideas about Research

Farmers involved in the sustainable agriculture movement have been calling for land grant institutions to conduct more on-farm research. However, this should be viewed as more than a call for relocating experimental plots from a research facility to a commercial farm. Farmers are asking to participate in a process for knowledge generation that can affect their lives and livelihood. When scientists control the selection of research objectives, they decide what information will be important to farmers. Of course, scientists assume that they are in touch with farmers' needs. Although there are direct and indirect communication channels from farmers to researchers, some critics have questioned their effectiveness (Thornley, 1990). The participatory approach strengthens the feedback from farmers to scientists and creates a way for farmers to affect research directly (Francis et al., 1990).

Projects conducted with active farmer participation are likely to have different objectives and designs than those designed and managed solely by scientists. Francis (1986) has described the characteristics of a research project that are thought to be important to farmers: plots of single or multiple machine widths, large enough to make a visual impact; treatments that will involve only modest investments or changes in equipment; the possibility of improving yields or profitability; and experimental conditions that represent their farms and farming operations. On the other hand, the characteristics of a research project that are believed to be important to an agricultural scientist are: statistically valid experimental design; uniformity of non-treatment variables; accessibility of the research site; and experimental conditions that represent a major production region so that results can be generalized. The differences between farmers' and scientists' views on what makes a good research project reflect the distinction between knowledge with high scientific validity and with high local relevance. The preference for knowledge generated through currently accepted scientific methods is so strongly held by

agricultural researchers that it is difficult for many to envision an alternative. Nevertheless, an argument can be made that the dominance of scientific knowledge is merely a social choice and that other means of generating knowledge are equally valid. Recently, the authority of agricultural science has been challenged by the sustainable agriculture movement. Although criticism of the dominant research model should be welcomed by scientists, it often is rejected as anti-science. Yet the essence of science is criticism, and scientists cannot afford to put their basic methods above evaluation. Indeed, science that is above criticism is in itself unscientific. It is useful to examine the dominant research method and the basis of the criticisms they have been receiving.

Scientific and Experiential Sources of Knowledge

Agricultural researchers are trained to identify measurable objectives, such as increased yield or improved product quality. They create an artificial environment in which most variables are uniform across an experiment, except the few variables under study. In this way they can determine the effects of a few factors, such as water or fertilizer, on the variable of interest. Appropriate statistical procedures provide a degree of reliability, an important component of validity. By attempting to falsify a hypothesis, scientists seek to identify and validate universal principles, thus producing simple, global truth. Universal solutions based on reproducible studies conducted under strictly defined conditions are then offered as recommendations to individuals. Customizing the information for specific situations is generally left to the farmer.

Farmers who work in a world full of variability often question the relevance of the researcher's narrowly defined objectives, uniform field conditions, and small plots that generally go hand-in-hand with appropriate statistical design. Farmers have to balance competing objectives, such as the desire for increased yield versus the desire for increased leisure time. The agroecosystem in which they work is not uniform, but complex and variable. Knowledge is desired not so much for universal understanding as for solving local problems. For farmers, an intuitive understanding of relationships among multiple variables, their confidence in their own observations, and the apparent success of practical solutions produce experiential knowledge that may have more immediate utility than scientific knowledge.

When scientists discount testimonial evidence that may have high local relevance, it is because information generated through experience doesn't meet appropriate scientific validity tests. When farmers discount research-derived knowledge that may have high scientific validity, it is because this information may have little practical utility. The farmer's "it worked for me" story is perceived by the scientist as little more than testimonial evidence, but by the farmer as relevant experience. Yet, scientific validity tests make knowledge useful to a larger community. Public researchers have objectives beyond solving a particular problem on a particular farm. They need to know that a practice will work on another farm, in another year. While farmers seek local solutions, scientists search for global truths.

The debate about whether farmers or scientists are the more appropriate source of agricultural knowledge will continue to undermine opportunities for communication unless it is resolved. The problem is the either/or dichotomy. Expert knowledge is incomplete by itself, whether it is from farmer-experts with their special intuitive sensitivity and understanding of local conditions, or from scientist-experts with training in research methods and an understanding of biological principles. Researchers validate knowledge through scientific methods that are empirical and generally quantitative. Farmers validate knowledge through rational experience that includes qualitative measures that are highly sensitive to local conditions. The suggestion that either is superior reduces the chance of meaningful communication and improvement of problematic situations. When professional researchers are seen as the primary source of new knowledge, the logical outcome is a system in which information on farming practices is "discovered" by researchers, "transferred" through extension education, and "received" by farmers. Farmers, extension educators and researchers are each viewed as separate components in the communication system. In participatory programs, the distinction between research activities and educational activities is not important. Knowledge is not viewed as a commodity for transfer from the informed to the non-informed, but the result of a continuing, cooperative process among partners or co-learners. Learning occurs when people become immersed in a meaningful experience based on a real problem. Participatory programs are based on the adult education theory that most adult learning occurs because of a person's desire to solve problems (Tough, 1982). That is, adults learn what they perceive they need to know, with the inquiry (research) process initiated by the learner. Freire (1990) agreed that knowledge emerges through the anxious and hopeful interaction of people living in community. Unlike the dominant model of unidirectional research and education, the participatory approach encourages social relationships based on mutual respect for each partner's abilities as both teacher and learner.

A Participatory Model for Research and Education

The participatory research model and a non-participatory approach may be thought of as two poles on a continuum, with the extent and quality of farmer participation being the primary controlling variable. Participatory research and education programs will most likely consist of variations of the multiple stage process described by Maguire (1987).

Problem identification

In a participatory program, the problem identification phase must include all relevant partners. Farmers, researchers, educators, consumers, community leaders, and representatives of agricultural supply and support groups discuss problems and opportunities in an open forum. Opportunities for free and open discussion within the chosen community must be institutionalized in order for democratic participation to occur (Evans and Boyte, 1986). This usually takes the form of county meetings,

but may be represented as a tillage club or perhaps even a computer network. During this phase, all partners (co-learners) represent their own viewpoints. Since farmers are the only ones who finally can implement new agricultural knowledge, they need to be actively involved in the process at this early stage. A few high priority problems are selected by farmers, with others helping to guide the process so that the objectives are both researchable and relevant.

Setting of objectives

Research objectives should be determined by farmers through dialogue and mutual agreement in consultation with researchers who can help define the objectives clearly. If partnership is to be achieved, objectives should reflect both the needs of farmers and the abilities of the participating researchers. Although good researchable questions can be generated by scientists, an explicit goal of participatory research is action based on research-derived knowledge. This is most likely to result from a partnership among the researchers, extension educators and farmers.

Selection of alternative solutions and project design

Participants develop their own theories to explain the cause of the problem and offer alternative solutions for testing. Although all partners are involved in the process, it should be recognized that researchers have special skills and knowledge that is critical at this stage. Participatory research does not mean that researchers give up all control. They must participate as full partners, employing their skills when appropriate. However, as the project is designed, researchers must be careful not to redesign the original, farmer-derived objectives or questions.

Implementation of the project

Each aspect of implementation should be conducted by the most appropriate member of the team. Implementation includes setup, care, observations, and data collection. Depending on the objectives of the project, it may be decided that the farmers should do it all themselves. Francis (1986) gives examples of projects that can be conducted on working farms:

- Tillage and residue management studies;
- Variety testing;
- Validation of soil test results.

An alternative is for both researcher and farmer to conduct various parts of the project. Here, there may be aspects of the research that can be conducted at a research facility as well as on a commercial farm. Examples are:

- Research on planting density;
- Comparisons of kinds and amounts of fertilizers;
- Comparisons of agricultural products.

It may be preferable to conduct the study at a research facility. This would be true, for example, for studies on:

- Nitrogen cycling in soils;
- Water movement through a soil profile;
- Maintenance of a plant breeding nursery.

Interpretation of the observations

Interpretation of research findings or educational impact should be made by everyone involved in the project. Individuals will "see" the world through the lenses of their personal experiences. It is critical that both farmers and researchers share their interpretations with each other and with the larger community.

Sharing of the results

In a non-participatory research project, the process usually ends with the publication of results. Conventional approaches to agricultural science divide knowledge into disciplines and treat such knowledge as a package for transfer. Researchers generally expect extension staff to deliver research results to the farmer. But the packaged knowledge may or may not be usable in the farmer's complex world, which doesn't recognize disciplinary boundaries. Implementation of new knowledge by the farmer is not part of the traditional research project design. On the other hand, the strong coupling of knowledge acquisition and subsequent action is a cornerstone of the participatory model. Education is built into the participatory research model, because strongly coupling the acquisition of knowledge to subsequent action is an explicit goal of the process.

Extension educators often organize meetings or develop publications to share experiences, opinions and new knowledge acquired through participatory research. Farmer observations and interpretations must be included in these outreach efforts. Because participatory research and education is a never-ending, circular process, the observations, data, and opinions from one year result in more questions for future research.

Participatory Programs

The international agriculture research community has accepted indigenous knowledge as an important component of development work. This concept has been recognized by academic researchers working under the banner of Farming Systems Research and Extension (Farrington and Martin, 1988), and codified in the *Manila Declaration on People's Participation and Sustainable Development* (Korten, 1990). Although some U.S. researchers (Rzewnicki et al., 1988; Shapiro et al., 1989) have demonstrated that on-farm research using large plots and active farmer participation can meet the conditions necessary for statistically reliable agronomic research, many agricultural scientists remain skeptical. The controversy over the relative value of experiment station and on-farm research has been going on since the beginning of the experiment station system (Kerr, 1987). Lockeretz (1987) and Taylor (1990) have reviewed this controversy more recently in relation to sustainable agriculture.

Citizen participation is a key component of many new community action programs (Habana-Hafner and Reed, 1989). Participation in a community in which both self-respect and group identity are valued provides the basis for cooperation and democratic action (Evans and Boyte, 1986). Bellah et al. (1991) make a com-

pelling argument that participation in the institutions that affect our lives is an important attribute of a healthy society. They contend that building institutions that encourage participation is a key ingredient for solving economic, social, and political problems. The movement within business to include workers in management decisions is further evidence that the participatory concept has practical utility (Plunkett and Rournier, 1991; Whyte, 1991).

Conclusion

The participatory research and education model is not presented as a practice to be used by all agricultural researchers under all circumstances. Rather, it should be seen as one mode of inquiry, to be used in particular cases, primarily for developing and adapting practices and products to solve complex, local problems.

It is interesting that the participatory model for agricultural research and education conforms to the megatrends described by Naisbitt (1982) as major directions for societal change, including:

- Change from an industrial to an information-based society;
- Shift from centralized to decentralized political power bases;
- More reliance on self-help rather than institutional help;
- Shift from a representative to a participatory democracy;
- Organization by networks instead of by hierarchies.

Introducing this research and education model to the land-grant community will not be a simple matter. The first reaction to a new conceptual framework for research and education is likely to be outright rejection, or even denial that it is new. However the exploration of a new (or rediscovered) institutional model followed by criticism, redesign, testing, and perhaps acceptance, is more likely during a period of unease or discomfort (Kuhn, 1970). The current discomfort in mainstream agriculture caused by the sustainable agriculture movement may provide the catalyst needed for a serious exploration and testing of participatory research and education programs in the U.S.

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Alternative Ag Can Reduce Soil Loss, Fuel Use, Says New Research

Adoption of logical alternatives to conventional cropping systems could reduce soil loss by as much as 70%, reduce fossil fuel and energy use by as much as 22%, and reduce commercial herbicide use on row-crops by as much as 40%, according to a 154-page study done at the University of Missouri/Columbia Sustainable Agriculture Systems Program by John Ikerd, Sandra Monson, and Donald Van Dyne.

According to **Potential Impacts of Sustainable Agriculture**, alternative practices also could reduce nitrogen fertilizer use by as much as 30%, reduce direct production costs by as much as 17%, and increase labor requirements by as little as 7%. For more information, contact University Extension, Agricultural Economics Department, 200 Mumford Hall, Columbia, MO 65211; (314)882-6533.

International Cover Crops Clearinghouse Offers Publications

The International Cover Crop Clearinghouse, established to exchange ideas, information, and experiences, is now making available **Cover Crop News**, a bimonthly newsletter, and several reports on the use of cover crops and green manures. For information, contact Milton Flores B., CIDICCO, Apartado Postal 3385, Tegucigalpa M.D.C., Honduras, Central America.

Mandatory supply controls versus flexibility policy options for encouraging sustainable farming systems

Thomas L. Dobbs and David L. Becker

Abstract. *We analyzed two sets of farm policy options, representing different ideological approaches to government involvement in agriculture, to estimate their effects on the relative economic attractiveness of "sustainable" and "conventional" farming systems. The mandatory supply control approach, through strict acreage limitations on program crops, represents a strong government role in commodity supply management. The Normal Crop Acreage approach, on the other hand, allows farmers greater flexibility in deciding what crops to grow. We used economic models of five pairs of case study farms in different agroclimatic areas of South Dakota, covering corn-soybean, spring wheat, and winter wheat growing regions. Mandatory restrictions on the planted acreage of "program" crops, including soybeans, were found to favor the conventional systems, because they induced high prices for crops that predominate in conventional systems, especially corn, soybeans, and wheat. In principle, however, mandatory acreage controls could require compliance with certain sustainable agriculture practices. Normal Crop Acreage (NCA) proposals can encourage greater use of sustainable farming systems. Where conventional corn and soybean production is relatively profitable, as in parts of eastern South Dakota, NCA options by themselves appear insufficient to induce changeovers to sustainable cropping systems. In wheat growing areas of northern and western South Dakota, however, where the two systems often are about equally profitable, NCA policies could promote sustainable systems, particularly if deficiency payments are not reduced for harvesting legumes and other non-program crops on NCA base. To have this positive effect, NCA policies must be introduced gradually and structured to limit adverse effects on the markets for legumes and other non-program crops that are important in sustainable rotations.*

Key words: agricultural policy, Normal Crop Acreage, planting flexibility, crop rotations, sustainable agriculture

Introduction

The 1985 Food Security Act was a landmark for U.S. farm policy in the attention it gave to environmental issues. The Conservation Reserve Program (CRP) and the various Conservation Compliance provisions tied together economic and environmental objectives of Federal farm policy. Debate leading to the 1990 Food, Agriculture, Conservation, and Trade Act (1990 Farm Bill) broadened the discussion to consider more explicitly the relationships between commodity provisions of farm programs and incentives or disincentives to adopt more environmentally sustainable farming systems. Thus, a variety of changes in commodity provisions were considered, some quite radical and others more modest. In the end, the basic structure of acreage limitations and target prices was left in place, with modest additional flexibility through a "Triple-base" program. Substantial flexibility was provided in a pilot Integrated Farm Management Program Option (IFMPO), however.

In the first two years after passage of the 1985 Food Security Act, some people proposed a fundamental departure from the current farm program, advocating mandatory acreage or output controls to drive market prices substantially higher. The intention of such proposals was both to raise farm income "through the market" and to lower taxpayer costs, particularly the costs of loan and deficiency payments. Senator Tom Harkin's proposed "Save the Family Farm" Act in 1986 was the most widely discussed of the supply control plans. By 1989 and 1990, discussion of mandatory supply control options had waned. However, interest in such options has a way of coming back every few years, particularly in the Great Plains, where the profitability of agriculture always has been marginal, where government involvement in agriculture generally has had a strong influence on profitability, and where populist politics are always just below the surface.

This article presents an analysis of two ideological extremes in farm policy. One is mandatory supply controls, the other consists of selected flexibility options. We examine the implications of both for the relative economic attractiveness of "sustainable" and "conventional" farming systems. The mandatory supply control option is represented by a program similar to Senator Harkin's of 1986. Flexibility op-

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tions are represented by two versions of a Normal Crop Acreage (NCA) plan put forth by the Bush Administration early in 1990 (U.S. Dept. of Agriculture, 1990). Economic models of five pairs of case study farms in different agroclimatic areas of South Dakota are used. These case farms cover corn-soybean, spring wheat, and winter wheat regions, representing the major cropping systems of the northern Great Plains.

For purposes of this article, "conventional" farming systems are those that use the cropping patterns, tillage practices, and commercial fertilizer and pesticide application rates that are typical for their respective areas. On the other hand, "sustainable" systems—sometimes called "alternative", "low-input/sustainable agriculture" (LISA), "low-input", or "regenerative" systems—either eliminate or greatly reduce the use of commercial chemical fertilizers and pesticides. They emphasize crop rotations, legumes, tillage practices, and cover crops for maintaining soil fertility, controlling weeds, and preventing soil erosion.

Background to the Study

Research at South Dakota State University (SDSU) on the implications of Federal farm policy for sustainable agriculture began in the mid-1980s with budget simulations of synthetic whole farms based on agronomic coefficients derived from early stages of farming systems work at the University's Northeast Research Station (Dobbs et al., 1988). The profitability of sustainable ("alternative"), conventional, and reduced tillage systems were compared in that research, using the Federal farm program and market prices prevailing in 1987 as a baseline, and simulating the effects of lower support (target) prices and of complete elimination of the farm program. This analysis partially supported the hypothesis that conventional farming systems are harmed more by reductions in Federal farm program support levels than are sustainable systems. However, there can be important exceptions. For example, sustainable systems in which unharvested clover serves both as green manure and as official set-aside lose some of their advantage if Federal set-aside requirements are reduced or eliminated when Federal price supports are reduced.

The policy focus of SDSU's sustainable agriculture research substantially expanded in late 1988 with receipt of a three-year grant from the Northwest Area Foundation. This grant has supported collection and analysis of detailed economic data on case sustainable farms across South Dakota. Data have been collected to support the following analyses: the comparative profitability of sustainable and conventional farms in different agroclimatic regions; the effects of government policies on the relative profitability of sustainable and conventional systems; and the potential implications for local rural economies of conversions from conventional to sustainable systems. The present article focuses on the second category. Analyses in the first and third categories are reported elsewhere (Dobbs et al., 1991; Dobbs and Cole, 1992).

We collected detailed economic information on crops, livestock, and other topics on twenty-two sustainable farms in different areas of South Dakota through on-farm interviews in early 1989. We had identified these twenty-two farms through a mail survey of sustainable farms conducted in 1988. Later we analyzed the economics of the cropping systems of twelve of them (Becker et al., 1990). Our analyses of the effects of public policies on the relative profitability of sustainable and conventional farms have been conducted using five of those twelve sustainable farms as case studies. The five farms represent sustainable farming systems in different agroclimatic areas in South Dakota (Figure 1). In the south-central and east-central areas, corn and soybeans predominate. Spring wheat is the principal crop in the northeast and northwest areas, and winter wheat is the primary cash crop in the southwest area. Detailed information about the crop rotations, cultural practices, and costs and returns associated with the five case sustainable farms is found in Taylor et al. (1990) and Becker et al. (1990).

These five sustainable farms are compared with five conventional farms, one of which (east-central) is an actual operating farm. For the other areas, we used various information sources to construct hypothetical ("synthetic") conventional farms to compare with the actual sustainable farms; sources included Agricultural Census data, Cooperative Extension and Soil Conservation Service reports, and interviews with key informants. Details of the crop systems and cultural practices for the conventional farms are found in Cole and Dobbs (1990).

Dobbs et al. (1991) report baseline profitability comparisons of these case sustainable and conventional farms under both 1988 and 1990 Federal farm program provisions. The 1988 comparisons were done both with and without the organic premiums that four of the sustainable farms receive for the certified organic portions of their crop production. Dobbs et al. (1991) also describe the effects of reducing Federal target prices by 25% from their 1990 levels, and of imposing a 25% tax on commercial fertilizers and herbicides.

In the following two sections, we present our analyses of supply control and flexibility policy options, using the sustainable and conventional case farm data just described. We discuss how the relative profitability of sustainable and conventional farms would be affected by pursuing either of these two general policy directions, compared to the Federal farm program in effect during the 1990 crop year.

The policy analyses reported here use a baseline in which acreage set-asides, market prices, target prices, deficiency payments, and loan rates are based on farm program provisions and projected market conditions for 1990. Market prices and deficiency payments in the 1990 baseline are based on data from the Food and Agricultural Policy Research Institute (FAPRI) of Iowa State University and the University of Missouri (Center for Agricultural and Rural Development, 1989), adapted to South Dakota price levels. Organic premiums received by some sustainable farmers are ignored here.

The results of any *ex ante* analysis of the impacts of proposed policies on the profitability of different farming systems depend on the projected price relationships for different crops. The details of our projected market price, support price, acreage set-aside, and related economic

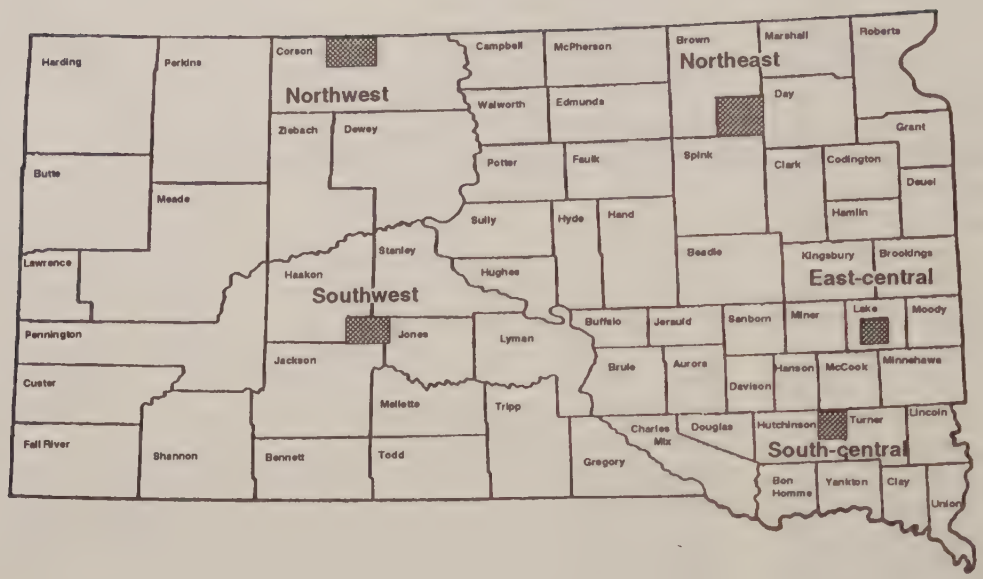

Figure 1. Locations of the case study farms in South Dakota.

data for the baseline and each policy scenario are given in Becker and Dobbs (1990) and Dobbs and Becker (1991); they also present the procedures and rationale for selecting and adapting particular projections.

Analysis of Acreage Control Option

Hertel (1990) provides an excellent review of the forms that supply controls might take. We have analyzed a mandatory acreage control program patterned generally after Senator Harkin's. (Harkin's 1986 proposal actually included both acreage controls and output quotas.) Macroeconomic analyses by Knutson et al. (1987) provided acreage reduction and related price adjustment parameters that we adapted for our analyses. Minimum price supports, in the form of loan rates, were set at 72% of parity in 1990. There are no target prices or deficiency payments under this option. Relatively high (33%) mandatory acreage set-aside requirements were assumed for program crops, including soybeans, in attempts to raise market prices to support levels.

The parity-related crop prices are high in relation to baseline levels. The 1990 South Dakota acreage control market/loan prices, derived from Knutson et al. (1987), are shown in Table 1. The 1990 FAPRI baseline returns per bushel for South Dakota, which include the higher of market prices and loan levels, plus applicable deficiency payments, also are shown for comparison. Prices under supply control exceed "effective" 1990 baseline prices (market or loan prices plus deficiency payments) by amounts ranging from 39% for oats to 102% for soybeans. This article reports comparisons with a 1990 baseline. Becker and Dobbs (1990) use both 1988 and 1990 baselines, and provide detailed support data and analytic results of the supply control analyses.

Because of the high crop prices associated with this supply control option, net farm income attributable to crops increases greatly on both conventional and sustainable farms (Table 2), but more so on the conventional farms: an average increase of $47/acre on the five conventional farms, compared to $25/acre on the sustainable farms. In the eastern regions, the profitability advantage held by conventional farms in the baseline scenario is increased by the supply control option. In the western regions, the supply control option causes the conventional systems to move from less profitable (in the northwest) and equally profitable (in the southwest) to more profitable than the sustainable systems. This general pattern of increased relative profitability for the conventional systems is due primarily to the larger proportion of cropland in the conventional systems planted to crops that benefit from the very high support prices, especially corn, soybeans, and wheat. The sustainable systems have larger proportions of other crops, including forage legumes, millet, and buckwheat. We assumed that prices of the uncontrolled crops do not change under the supply control option. In reality, the prices of at least some uncontrolled crops would probably rise, although not by as much as prices of the controlled crops; this could offset some of the profit advantage of the conventional systems under the mandatory acreage control option.

These case comparison analyses indicate that a mandatory supply control option implemented simply through acreage controls may favor conventional over sus-

Table 1. Crop prices and returns ($/bu), South Dakota, 1990.

	Baseline return	Acreage control price
Corn	2.65	4.09
Soybeans	4.99	10.09
Wheat	4.03	5.77
Oats	1.68	2.34
Barley	2.15	3.49
Grain sorghum	2.33	3.71

Table 2. Mandatory acreage control analysis, 1990; net income over all costs except management ($/acre).

	Baseline		Mandatory acreage controls	
	Sustainable	Conventional	Sustainable	Conventional
South-central	-10	14	37	72
East-central	9	41	37	130
Northeast	-19	-12	-2	15
Northwest	-20	-23	-4	7
Southwest	5	5	23	38

tainable farming systems. Others have drawn similar conclusions. Hertel (1990), for example, notes the incentive farmers have to raise yields by increasing the use of purchased chemicals when planted acreage is restricted. Controls on output, as opposed to acreage, on the other hand, encourage greater use of land, relative to purchased inputs. This makes them more compatible with "lower variable input" agriculture (Hertel, 1990). Thus, acreage controls probably affect yield and input application rates, besides the effect on profits associated with crop mix, brought out in our case analyses.

Dobbs et al. (1988) pointed out circumstances in which acreage set-aside requirements appear compatible with sustainable practices, and even may encourage them. This can happen when non-harvested legumes such as sweet and red clover, which are part of some sustainable cropping systems, satisfy farm program set-aside requirements. However, when set-asides are set at levels that induce very high prices for restricted crops, as in the acreage control option treated in this article, the relatively favorable effects for conventional systems may prevail.

Other effects of strong supply control options may preclude their adoption by Congress anyway. Such effects have been analyzed and discussed elsewhere (e.g., Hertel, 1990; Young et al., 1989). They include adverse effects on export trade and on consumer prices. Also, livestock producers are hurt in the short run by the resulting higher feed grain prices. The net income calculations in our case analyses did not account for that effect on conventional and sustainable farms that have livestock.

Theory and experience tell us that sustained net income increases tied to a fixed factor of production eventually are reflected in higher prices for that factor. In this case, land with acreage allotments for the restricted crops would be bid up in price if the mandatory acreage control program was expected to remain in place. Consequently, the relatively high figures for "net income over all costs except management" for the acreage control program shown in Table 2 would decline. This is not a problem for farmers already owning land when the severe acreage restrictions are put in place, because they can capture the higher capitalized land values. However, the "farm income problem" for renters and new (or prospective) owner-operators recurs. This creates political pressure for ever higher support prices or alternative income support programs.

Analysis of Flexibility Policy Options

The Normal Crop Acreage (NCA) proposal considered in this article incorporates more planting flexibility than has been available in recent Federal farm programs, including the 1985 Food Security Act. The NCA option we analyzed is patterned after the one in the Bush Administration's proposal for the 1990 farm bill (U.S. Dept. of Agriculture, 1990). A normal crop acreage for a farm is established by summing the farm's individual crop acreage bases and historical plantings of oilseeds (soybeans, sunflowers, rapeseed, and canola). Any combination of program crops and oilseeds may be planted on the NCA. The planting and harvesting of non-program or non-oilseed crops on the NCA results in a reduction in deficiency payments. The only oilseed crop included in our NCA calculations was soybeans. (None of our case farms grew sunflowers, rapeseed, or canola.) Assumed set-aside rates and target prices were the same as the 1990 baseline.

We analyzed two versions of this NCA option. One version was close to that proposed in early 1990 by the Bush Administration (U.S. Dept. of Agriculture, 1990). Deficiency payments in that option are based on historical plantings and base yields. That is, they essentially are "decoupled," except for deductions based on any harvested non-program or non-oilseed crops on the NCA. In the other NCA version, we did not make a deduction from deficiency payments for harvested legumes and other non-program crops (such as millet and buckwheat) planted on the NCA base. In both versions, set-aside requirements had to be met, meaning legumes or other resource conserving crops could not be harvested on the set-aside acres.

In analyzing the effects of an NCA option, we first assumed that some sustainable farms would slightly modify their cropland use toward their "ideal" rotation. Some sustainable farmers have been com-

promising their rotations to comply with set-aside requirements and to avoid losing program base acres. We wanted to determine the implications of an NCA for their moving completely to the particular rotations they were trying to practice (e.g., a soybeans-corn-small grain-alfalfa 4-year rotation, in one case). Next, we assumed that each conventional farm adopted the same "ideal" rotation as the sustainable farm in its region, and the fertility, weed control, and other cultural practices of the sustainable farm. Also, harvested crop yields now were assumed to be the same as for the sustainable farm. Each conventional and sustainable farm kept its historical crop acreage bases and base yields, however. Thus, the resulting net income, including government payments, for each conventional farm differed somewhat from its matched sustainable farm. For purposes of this article, we are most interested in the implications of NCA policies for conventional farms that convert to sustainable practices.

Crop prices used in the NCA calculations were adapted from data contained in Westhoff and Stephens (1990). We assumed that crop prices would differ from those in the 1990 baseline after a period of adjustment. Corn, barley, oats, and grain sorghum prices are higher under the NCA option and wheat and soybean prices are lower. Prices for non-program crops other than soybeans were assumed to be the same as in the baseline. Detailed price and related economic assumptions are contained in Dobbs and Becker (1991).

Results of analysis of the two NCA policy options are shown in Table 3. The first two columns contain the 1990 baseline net income over all costs except management for each sustainable and conventional farm. The results for each "ideal sustainable" and "conventional-converted-to-sustainable" farm under the two NCA options are shown in the remaining four columns. The two center columns show net incomes under the "standard" NCA option when each farm uses "ideal" sustainable rotations and sustainable cultural practices, but retains its own program payment base. The two rightmost columns also show each farm's net income with "ideal" sustainable rotations and practices, again with its own program base; however, the NCA is modified so that there is no penalty for harvesting legume and other non-program crop acres that are part of the sustainable rotation and that also occupy part of the NCA base.

Table 3. Normal Crop Acreage (NCA) analysis, 1990; net income over all costs except management ($/acre).

	Baseline		NCA (Standard)		NCA (No deficiency payment reduction)	
	Sustainable	Conventional	Sustainable	Conventional converted to sustainable	Sustainable	Conventional converted to sustainable
South-central	-10	14	-16	-9	-16	-9
East-central	9	41	5	4	9	12
Northeast	-19	-12	-16	-17	-14	-12
Northwest	-20	-23	-17	-15	-17	-15
Southwest	5	5	7	8	7	10

The NCA's effects in the south-central and east-central regions differ from those in the northeast and western regions. In the former two, both the sustainable and the conventional-converted-to-sustainable farms appear worse off under the standard NCA option. The farms in these two regions are hurt by lower soybean prices, which are assumed to be $4.29/bu under the NCA options, compared to $4.99/bu in the 1990 baseline. In the NCA options we analyzed, there were no deficiency payments to help offset the lower soybean price. In contrast, although the wheat price also falls under the NCA option, the resulting higher deficiency payments help offset that decline.

Other reasons that net incomes fall for the conventional-converted-to-sustainable farms in the south-central and east-central regions are: 1) they grow less corn when they switch to the sustainable rotations; 2) corn deficiency payments per bushel of historical base are reduced, because of higher market prices for corn under the NCA; and 3) the east-central converted farm substantially reduces its soybean acreage, and its soybean yield is less than with conventional practices.

Removing the penalty for harvesting legumes and other non-program crops on NCA base (the second NCA option, in the two rightmost columns of Table 3) does not make any difference in the south-central region, because these crops are not part of the sustainable rotation there. It does make a difference in the east-central region, however, where alfalfa is part of the sustainable rotation. This version of the NCA option allows the sustainable farm to switch to its "ideal" rotation without any loss of net income. Removing the penalty for harvesting legumes on NCA base adds $8/acre to net income of the conventional-converted-to-sustainable farm, compared to the standard NCA option; however, it still leaves net income of that farm far below its 1990 conventional farm baseline.

The NCA policy options have a more positive effect on net farm incomes in the northeast, northwest, and southwest regions. In most cases, both the sustainable and the conventional-converted-to-sustainable farms make at least as much income under either NCA option as under the 1990 baseline scenario. One exception is the northeast conventional-converted-to-sustainable farm, which earns $5/acre less than the baseline under the standard NCA option. However, when the penalty for harvesting legumes and other non-program crops on NCA base is removed, this farm recoups most of its historically based deficiency payments and has the same net income (-$12/acre) as in its 1990 baseline.

Removal of the penalty for harvesting legumes and other non-program crops on NCA base does not affect the northwest region farms, because sweet clover as a green manure is the key legume in the sustainable system there, not a harvested legume such as alfalfa. Removing this penalty has some effect on the southwest conventional-converted-to-sustainable farm. Because harvested alfalfa, millet, and buckwheat are part of the sustainable rota-

tion in this region, some historically based deficiency payments on that farm are recovered under the modified NCA option, compared to the standard option.

There is little difference in the profitability of sustainable and conventional farms in the wheat-growing regions of northern and western South Dakota under baseline conditions. Thus, it is not surprising that NCA policy options, particularly ones that avoid government program payment penalties for harvesting legumes and such non-program crops as millet and buckwheat, modestly encourage farmers to convert from conventional to sustainable systems, or at least do not discourage them. A key assumption underlying that conclusion, however, is that the macroeconomic effects of NCA policies do not significantly lower the prices of alfalfa hay, millet, buckwheat, and other crops characteristically used in sustainable rotations. Concern about just such potential price declines has caused some sustainable agriculture proponents to advocate gradual, phased-in flexibility. Flexibility that is phased-in, and perhaps limited, could remove some constraints to sustainable rotations without causing rapid, price-depressing expansions in hay and specialty crops such as millet and buckwheat.

Young and Painter (1990) also found that NCA policies tend to encourage some sustainable systems in a wheat growing region (in their case, the Washington-Idaho Palouse region). Their analysis explicitly accounts for the important fact that NCA options protect against erosion of program base when conventional farmers convert to sustainable rotations that incorporate green manure crops.

Faeth et al. (1991) recently analyzed an NCA option similar to the "standard" option of this article. Their analysis was applied to case farming systems in Nebraska and Pennsylvania, covering a range of "conventional" and "alternative" or "sustainable" systems. Some of the Nebraska systems have characteristics similar to ones we analyzed in the corn-soybean areas of south-central and east-central South Dakota. The study concluded that the "NCA doesn't alter the relative economics of various rotations in Pennsylvania or in Nebraska" and that the "NCA's limited flexibility precludes extensive rationalization of resource use in agriculture" (Faeth et al., 1991, p. 18). However, the authors say that in Nebraska, the NCA option "improves" the financial attractiveness to farmers of 4-year rotations, relative to conventional rotations (Faeth et al., 1991, p. 51).

Conclusions

Two sets of farm policy options were analyzed in this article, representing very different ideological approaches to government involvement in agriculture. The mandatory supply control approach, through strict acreage limitations on program crops, represents a strong government role in commodity supply management. The Normal Crop Acreage (NCA) approach, on the other hand, acknowledges the historical and economic context of present U.S. farm commodity program "entitlements," but calls for much greater flexibility in farmer decision making about crops to grow. Both approaches have distinct implications for farm income and for incentives or disincentives to adopt more environmentally sustainable farming systems.

Mandatory acreage controls on "program" crops (including soybeans) were found to favor the conventional farming systems. This is primarily because of the very high prices that those restrictions induce for crops that predominate in conventional systems, especially corn, soybeans, and wheat. In principle, one could design a mandatory acreage control program that requires compliance with certain sustainable agriculture practices, such as the use of crop rotations that include legumes. To some extent, this is done already with "conservation compliance requirements" attached to the benefits of current Federal farm programs. Alternatively, taxes on commercial chemical inputs might be used to partially counter the tendency of mandatory acreage controls to increase the application rates of those inputs. Although output controls are preferable in principle to acreage controls, output controls can be very difficult to design and administer in practice. Thus, policy analysts should devote more attention to ways of making acreage controls compatible with sustainability objectives.

In any event, for various other policy reasons, including international trade and consumer price considerations, there is heavy opposition in many quarters to "strong" mandatory supply control options for grains in the U.S. Schnittker (1990) provides a good discussion of recent political prospects for different farm policy options.

Normal Crop Acreage proposals do offer some promise for encouraging greater use of sustainable farming systems. Where conventional corn and soybean production is relatively profitable, as in parts of eastern South Dakota, NCA options by themselves appear insufficient to induce changeovers from conventional to sustainable cropping systems. In wheat growing areas of northern and western South Dakota, however, where conventional and sustainable systems often have nearly equal profits, NCA policies could significantly stimulate conversions from conventional to sustainable systems, particularly if deficiency payments are not reduced for harvesting legumes and other non-program crops on NCA base. For this to happen, it may be necessary to introduce an NCA program gradually and structure it in ways that limit adverse effects on the markets for legumes and other non-program crops important in the rotations of current sustainable farmers.

Although the NCA was not incorporated in the 1990 Farm Bill, the ideology of greater flexibility was incorporated in the pilot Integrated Farm Management Program Option (IFMPO). This option allows deficiency payments to be paid on base acres planted to certain resource conserving crops (except on set-aside and "triple base" acres), as if the traditional program crop had been planted. Also, a portion of the set-aside land can be grazed or harvested for hay if it is planted to a resource conserving crop. The program is extremely complex, and it was initially given very little visibility by the USDA. Also, there was a great deal of confusion about implementation guidelines at the time of 1991 program signup. We have conducted some analysis of the IFMPO with selected sustainable and conventional case farms

(Dobbs and Becker, 1991), and additional analysis is underway. Many sustainable agriculture advocates believe that increased flexibility is needed, but that it must be introduced in the context of government support for environmental quality goals and goals for maintaining incomes on moderate-sized family farms. We do not yet know whether the IFMPO, some version of NCA, or another approach would best accomplish both the income and environmental goals of sustainable agriculture.

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Monthly Information Sheets Highlight SARE Research

Monthly information sheets now being produced by the Sustainable Agriculture Network and distributed by the regional offices of the Sustainable Agriculture Research and Education program (SARE, formerly LISA) highlight research and other projects in the SARE program and EPA's Agriculture in Concert with the Environment (ACE) program. The first information sheet was a condensed version of the SARE program's annual report; the second, just published, is an overview of SARE and ACE projects aimed at controlling weeds with fewer herbicides.

To receive these monthly information sheets and other publications from the SARE program, contact the program's regional director in your region: West—David Schlegel, University of California—DANR, 300 Lakeside Dr., 6th floor, Oakland, CA 94612-3560; North Central—Steve Waller, 207 Agriculture Hall, University of Nebraska, Lincoln, NE 68583-0704; South—William Brown, Ag Experiment Station, Louisiana State University, Baton Rouge, LA 70893-5055; Northeast—Fred Magdoff, Plant & Soil Science Dept., University of Vermont, Burlington, VT 05405.

Sustainable Ag Network Now Connected by "SANlink"

Members of the Sustainable Agriculture Network (SAN) are now connected by "SANlink," which coordinates the network's functions and keeps track of the activities of a widely dispersed network and steering committee. SANlink was established as part of the Alternative Farming Systems Information Center at the National Agricultural Library in Beltsville, MD. SAN Coordinator is Gabriel Hegyes, who also works part-time as Information Manager at the IAA. For more information about SAN or SANlink, contact Jill Auburn at (916)-757-3278.

Comparison of taste quality between organically and conventionally grown fruits and vegetables

Dov Basker

Abstract. *Panels of 40 to 60 "non-expert" consumers attempted to distinguish between the taste of organically and conventionally grown fruits and vegetables. Wherever possible, samples of the two types of produce were obtained by picking them in the growing orchards/fields to avoid any question of authenticity, and cold-stored without treatment under the same conditions, for periods reflecting their shipping time to markets. Some physical, chemical, and instrumental analytical tests were also performed. No consistent preference pattern emerged. For grapefruit, grapes, carrots, spinach, sweet corn and tomatoes, the differences in hedonic ratings and scores between the two types of produce were not significant. For mangoes and orange juice, the conventional type was preferred, while the reverse was true for bananas; in each of these three instances the result could be ascribed to fruit being tasted closer to its optimum maturity.*

Screening tests were performed to detect any traces, at the parts-per-billion level, of chlorinated hydrocarbons and organophosphorus compounds used as pesticides, or their degradation products. No traces were detected in any of the samples examined (bananas, grapes, carrots, spinach, sweet corn or tomatoes), whether organically or conventionally grown. In those samples examined (bananas, grapes, carrots, spinach, sweet corn and tomatoes) by quantitative tests for the three major fertilizer elements used conventionally (NPK), nitrogen and phosphorus concentrations were not consistently greater, while potassium concentrations were either equal or greater, than in the organically grown samples. Among the anion analyses performed on orange juice, grapefruit juice, carrots, spinach and tomatoes, nitrates and particularly nitrites either were not detected, or occurred at negligible concentrations in all samples. Phosphates were found at higher concentrations, but not significantly so, in four of the five organic products tested; no phosphates were detected in either type of tomatoes.

Key words: organic fruits, organic vegetables, taste panels, hedonic preferences

Introduction

In Israel and in other countries, organic agriculture differs from the more conventional type by its avoidance of synthetic chemicals for soil preparation, fertilization and pest control. These are replaced, respectively, by thermal disinfection, manure/compost/guano, and biological pest control (Beharrell and MacFie, 1991). The production methods used are similar but not identical to those of "sustainable" (Reganold et al., 1990) or "alternative" agriculture (Brugger et al., 1987). Conventional agriculture reputedly has higher yields because limiting stresses on plants are reduced, which allows them to attain their genetic potential (Minotti, 1975). Moderate stresses under organic farming could result in sensory advantages to the consumer, but experimental evidence would be required to verify any such claim. On the other hand, as consumers have become accustomed to conventionally grown produce, the taste of the organically grown type might be less preferred. This study provides a preliminary examination of these points.

An informal, unquantified hypothesis sometimes offered for why organic produce "tastes better" than the conventional type is that lower levels of NPK fertilization result in smaller unit weight, which yields a higher concentration of sugars, total dissolved solids, and total dry matter. In turn, this results in better taste. Preliminary data were collected regarding the first two points while sampling to study taste.

The experimental plan of this study was to compare a few samples of various organically and conventionally grown fruits and vegetables, using taste panels of consumers (Amerine et al., 1965; American Society for Testing and Materials, 1968; von Sydow, 1975; Jennings, 1977; British Standards Institution, 1980; Solms et al., eds., 1987; Moskowitz, ed., 1988). Most assessors were researchers, technicians and clerks at the Agricultural Research Organization who had previous experience with taste panel procedures, but were not preselected in any way. Each experiment can be interpreted only within its own restricted range, but broader conclusions may be possible if all the experimental results are considered together.

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Materials

The choice of suitable commercial, certified organically farmed plots was constrained by the need for similar comparative commercial conventional plots, with produce of the same variety growing at the same time on similar soil under similar climatic conditions. The produce also had to be ready for harvesting at the same time and at approximately the same physiological growth stage. All of these considerations could not always be met, and some compromises had to be made; also, by the time laboratory tests could check "ripeness" analytically, the produce had already been selected on availability, visual and other criteria. In consequence, this parameter confounded the background variables, but as it was random, about as many instances would be expected to favor organic samples as conventional ones. Individual sample size was generally about 10 kg.

The tomatoes (*Lycopersicon esculentum* Mill., var. 'F-121') were grown in commercial greenhouses in the Shalom district of the northwestern Negev. Six samples were drawn: three from different organic growers and three from different conventional growers. All samples were picked on 22 February, with those from the "breaker" to "pink" stages selected for study. Picking at this physiological ripeness stage, at least for some varieties, has been shown to result in approximately optimum taste quality (Lapushner et al., 1981). On the following day, all samples were transferred to a simulated transport storage room held at 12°C and 90% relative humidity (r.h.). Six days after picking, the samples were transferred to simulated shelf conditions at 20°C and 85% r.h.

The variety of carrots (*Daucus carota* L.) sampled, 'Nairobi,' is not the principal one grown organically in Israel, but most of the conditions were met. The samples were obtained from commercial fields in the Bet She'an region. Samples were harvested on 8 April, 195 days after sowing the organic crop and 179 days after sowing the conventional crop. Both were rinsed to remove adhering earth, sorted visually into two size groups (larger and smaller), giving a total of four samples, and packed in perforated plastic bags and transferred the same day to 0°C storage.

Oranges (*Citrus sinensis* Osbeck, var. 'Valencia' on Rough Lemon rootstock), both organically and conventionally grown, were obtained from a 25-year-old grove on sandy soil in the Eshkol region of the northwestern Negev. They were both picked on 17 April and stored without treatment at 6°C and 80% r.h. A further organically grown 'Valencia' sample was picked on 23 April from similar groves on sandy soil in the central Sharon region; a comparative conventional sample was obtained from a nearby packing house, without chemical treatment. Storage was as above.

Grapefruits (*Citrus paradisi* Macf., var. 'Marsh Seedless' on Rough Lemon rootstock), were obtained from a 28-year-old grove on sandy soil in the Eshkol region of the northwestern Negev. Both samples were picked on 17 April and stored without treatment at 11°C and 80% r.h. The non-organically grown sample had been fertilized chemically but not treated with chemical pesticides; therefore it is designated as Part-conventional.

Frozen chopped spinach (*Spinacia oleracea* L.), one sample each from crops in both organic and conventional fields, was obtained from current April production courtesy of an industrial processor. The exact growing regions were not identified. The recommended storage temperature of -18°C was maintained until the samples were required for testing.

Bananas (*Musa sapientium* L., var. 'Cavendish-Paz'), both organically and conventionally grown, which had flowered during the period 10-20 September, were harvested in May from chalky soil groves 60 m above sea level in the central Shefela region, and the Bet She'an region, 200 m below sea level. Samples were stored at 10°C and 90% r.h. Ethylene was not used to regulate ripening of any of the samples, so that visually they were highly variable even within a bunch. The two organic samples both ripened before the two conventional ones, with major differences becoming apparent between upper and lower reaches of a single bunch, and minor differences within individual hands. For comparative testing, bananas at ripening stages 4-6 (von Loesecke, 1950) were selected.

Kernels of frozen sweet corn (*Zea mays* L., var. 'Jubilee)' one sample each from organic and conventional fields, were obtained from current June production by courtesy of an industrial processor. Their growing regions were rather disparate, and they were harvested one day apart. The recommended storage temperature of -18°C was maintained until the samples were required for testing.

White grapes (*Vitis vinifera* L., var. 'Perlette'), both organically and conventionally grown, were picked on 8 July in the Bet She'an region. Both samples were stored at 0°C and 95% r.h.

Mangoes (*Mangifera indica* L., var. 'Maya') were obtained from groves in the Eshkol region of the northwestern Negev. They were picked on 20 August while green, at about maturity stage "B" (Cheema and Dani, 1934; Srivastani, 1967), stored without treatment at 14°C and 85% r.h. for 11 days, and then transferred to simulated shelf-conditions at 20°C and 85% r.h. for a further three days. Three samples of nominal sizes "18" and "15/18" were obtained, respectively, from one organic and two conventional growers. The fruit ripened during storage, one side developing the characteristic "blush" and the other becoming yellow; the two sides were tested separately.

Sensory Methods

When four or more samples were available for comparison (tomatoes, carrots, orange juice, bananas and mangoes), each assessor was requested to do the following: rank them in order of personal preference (first preference = 1, etc.); rate each on a 15-point nonparametric pictorial scale (Basker, 1989); and score each on a scale from zero to ten units. When only two samples were available for comparison (grapefruit, spinach, sweet corn and grapes), they were presented as a triangular test (Helm and Trolle, 1946; American Society for Testing and Materials, 1968), that is, with one sample included twice. Each assessor was requested first to attempt to distinguish between the "pair" and the "singlet." For half the panel, the pair

was organic, and for the other half the arrangement was reversed.

All samples were coded with two-digit random numbers, and each assessor was requested to taste all the samples presented and then to answer the questions above. For rating, the scale is labelled in this report from "A" (highest possible rating) to "O" (lowest possible), with "H" as neutral. For scoring, zero represents a worst possible product, and ten a best possible. Ratings and scores represent two different methods of recording and interpreting assessors' subjective relative responses, the former on an ordinal scale and rigorous, the latter on the assumption that ratio-scale arithmetic is permissible. Occasional results were deleted if incompletely or erroneously recorded.

Tomatoes, cut longitudinally into eighths, were tasted by 52 assessors, seven days after picking (that is, after one day of simulated shelf storage). Carrots, coarsely grated, were tasted by 53 assessors, 24 days after harvesting. Oranges were juiced with a "Progress" household electric rose-head extractor after 29 days' storage for the Eshkol region samples, or after 23 days' storage for the Sharon region samples. The juice was strained coarsely, not heated, and tasted promptly by 62 assessors. Grapefruits were peeled manually, without removing the segments' membrane, after 22 days' storage, and tasted by 51 assessors. The two spinach samples (100 g portions) were heated for 150 sec in a 650W microwave oven, and generally allowed to cool to room temperature (20°C) before being tasted; salt was added at the discretion of the 49 assessors. Bananas were individually peeled after 15 days' storage, and tasted by 39 assessors. Sweet corn was treated like the spinach, and tasted by 56 assessors. Grapes were tasted after nine days' storage by 66 assessors. Mangoes were cut to separate the "blush" and yellow halves, then cut radially and peeled thinly, each piece extending from skin to stone, to include the reported range of acidity variation (Srivastani, 1967), and tasted by 32 assessors.

Analytical Methods

Except for spinach and grapes, the produce units were weighed individually. Samples of tomatoes, spinach, sweet corn, grapes and mangoes were pureed, and the purees centrifuged (15,000 rpm for 30 min or more) to give colorless sera; samples of orange and grapefruit juices were treated similarly; carrots were juiced with a "Santos" carrot juicer, and treated similarly; bananas were peeled, the pulp centrifuged, and the sera sonicated (30 min in a 300W bath at 35 kHz) to reduce their viscosity, although this still was not sufficient for anion analysis. The sera were examined for pH, titrable acidity, refractive index (reported on the sucrose [Brix] scale at 20°C [Association of Official Analytical Chemists, 1970]), sugars (glucose, fructose and sucrose) and some anions by high-performance liquid chromatography (HPLC) as described below. Total sugars are reported as invert sugar. The refractometric Brix is often considered an estimate of the content of total dissolved solids in fruit and vegetables; with this datum, the content of insoluble solids was determined indirectly (Basker, 1973). Other samples of tomatoes, carrots, spinach, banana pulp and sweet corn were dried in a well-ventilated oven at 65°C and atmospheric pressure to constant weight (after approximately seven days) to determine their total dry matter content (tomatoes, banana pulp, sweet corn); the residues were used to determine elemental constituents using an autoanalyzer or by flame photometry.

A Hewlett-Packard (Waldbronn, Germany) HP 1090 Liquid Chromatograph was used for HPLC analysis. For sugars, a calcium-form Technicon (Tarrytown, NY) C-3 cation exchange resin in a 500 by 6 mm column with an 85°C water-jacket, an Erma Optical Works (Tokyo) model ERC-7510 refractive index detector and a Hewlett-Packard (Avondale, PA) HP 3390A reporting integrator were used, with aqueous 0.02% w/v $CaSO_4.2H_2O$ and 0.5 ppm pentachlorophenol (a bacteriostat) as the eluent. For anions, 0.5 ml of serum was passed through an Extra-Sep cartridge containing 200 mg C18 resin (Lida Manufacturing Corp., Bensenville, IL; catalog no. 2021-50) to eliminate dissolved organic constituents, followed by a Vydac (Hesperia, California; catalog no. 3001C-405) anion exchange column and a Hewlett-Packard (Waldbronn, Germany) HP1040A diode array detector set at wavelength 280 nm, with a built-in data-processing unit (DPU), and with 1 mM aqueous potassium hydrogen phthalate, adjusted to pH 7.4 with triethylamine, as the eluent.

Screening tests were performed to seek residues of chlorinated hydrocarbons and organophosphorus pesticides (McMahon and Sawyer, 1986). The unwashed organic and conventional samples of carrots, spinach, sweet corn, grapes and tomatoes (with calyx attached), were analyzed as received, but bananas were peeled to remove the inedible portion.

Results

The results of the taste identification tests are presented in Table 1, where the surplus proportion of correct identifications is designated the plurality (Basker, 1981); for the triangular test, plurality equals the total proportion of correct identifications minus 1/3; statistical significance was evaluated by the chi-square model (Basker, 1988a). A demonstrated taste-identity difference, as for the grape samples, does not imply any preference. However, identification tests permit data corrections for the results due to "lucky guessers" (Woodward and Schucany, 1977; Basker, 1988a), and, therefore, they are concealed among the correct identifications. For the triangular test, the number of lucky guessers is (statistically) half the number of incorrect identifiers. The ratings and scores of the latter provide estimates of those of the former, allowing correction calculations to be made.

Hedonic taste preference ranks are reported as their means, and their differences were evaluated as described by Basker (1988b,c). Virtual rating medians were calculated according to Basker (1989); F.9, for example, implies that the median lies between F and G, approximately 9/10 of the way from F. For each sample, the proportion (%) of ratings was also calculated down to the overall median; half the ratings of all samples of a given product lie in this range. Differences in the rating distributions were evaluated by the Dwass-Gabriel procedure for the Wilcoxon-Mann-Whitney U-test (Sokal and Rohlf, 1981, pp. 437-440). Differences among the mean scores, and among other means, were evaluated by Duncan's (1955) multiple range test. Whenever these tests were inapplicable, the chi-square test (Siegel, 1956), the Kolmogorov-Smirnov two-sample test

Table 1. Taste identification test results.

	Plurality	Significance
Grapefruit	0.04	NS
Spinach	0.24	*
Sweet corn	0.19	NS
Grapes	0.33	***

The following abbreviations apply in this table:
* = significant, $p < 0.05$
*** = significant, $p < 0.001$
NS = not significant

Table 2. Comparative taste results.

Product	Sample	Nonparametric ratings		Mean scores ± S.E.
		Median	% to overall median	
Tomatoes	Organic	F.0	52	6.6 ± 0.2
			NS	NS
	Conventional	F.5	48	6.6 ± 0.2
Carrots	Organic	F.0	47	6.5 ± 0.2
			NS	NS
	Conventional	E.6	53	6.7 ± 0.2
Orange juice	Organic	G.9	34	5.7 ± 0.2
			**	***
	Conventional	D.7	66	7.2 ± 0.2
Grapefruit	Organic	E.3	49	6.4 ± 0.5
			NS	NS
	Part-conventional	E.3	51	7.3 ± 0.5
Spinach	Organic	G.4	46	6.2 ± 0.5
			NS	NS
	Conventional	F.7	54	6.9 ± 0.3
Bananas	Organic	C.7	71	7.7 ± 0.2
			**	***
	Conventional	F.8	29	6.0 ± 0.2
Sweet corn	Organic	C.2	49	8.2 ± 0.4
			NS	NS
	Conventional	C.2	51	8.0 ± 0.4
Grapes	Organic	E.6	39	7.0 ± 0.3
			NS	NS
	Conventional	D.1	61	7.5 ± 0.3
Mangoes	Organic	F.9	38	5.3 ± 0.2
			*	**
	Conventional	D.9	62	7.2 ± 0.2

The following abbreviations apply in this table:
* = significant, $p < 0.05$
** = significant, $p < 0.01$
*** = significant, $p < 0.001$
NS = not significant

(Siegel, 1956; Pearson and Hartley, 1972) and Student's t-test (Gore, 1952) were used. In each listing below, identical lower-case letters indicate results that do not differ significantly ($p < 0.05$).

The taste results are shown in Table 2. No significant differences in either the nonparametric rating or the 0 to 10 score were found for tomatoes, carrots, grapefruit, spinach, sweet corn, or grapes. (For mangoes, no significant mean taste differences were found between the "blush" and yellow halves of any sample, and the results from the two halves therefore were pooled.) The panel preferred the conventional orange juice and mangoes, but the organic bananas. Even for these products, however, there was substantial overlap between the organic and conventional samples, as shown in Table 3.

For carrots, significant differences were found among the mean unit weights (g) as follows:

	Large	Small
Organic	140 a	92 a
Conventional	109 a	66 b

These differences are ascribed to the longer growing period of the organically grown samples, and are thus not relevant to the comparison with conventionally grown ones.

For all products, unit weight, pH, refractometric Brix, total sugar content and dry matter results were pooled and summarized in Table 4, and elemental and anion analyses in Table 5. The "ripeness" parameters of some samples were found to differ (Table 6), although statistical significance was generally lacking, possibly because of the small numbers of analyses involved.

No pesticide residues, or their degradation products, were detected in any of the samples examined (bananas, grapes, carrots, spinach, sweet corn and tomatoes), whether organically or conventionally grown. The detection level of these screening tests was approximately 5 to 10 parts per billion.

Discussion and Conclusions

The principal parameter investigated in this study was taste. A total of 460 assessments of 29 samples gave nearly 1,600 independent responses covering five fruits

Table 3. Results for products with significantly different ratings.

Product	Samples	Mean pref. rank	Nonparametric ratings		Mean scores
			Median	%to overall median	
Orange juice	Organic	2.6 b	F.9	44 b	6.4 b
		3.4 c	I.0	25 c	5.0 c
	Conventional	2.3 b	E.3	56 ab	6.9 ab
		1.7 a	D.2	75 a	7.6 a
Bananas	Organic	2.4 b	D.6	55 b	6.9 b
		1.5 a	C.0	86 a	8.5 a
	Conventional	3.1 b	G.0	28 b	5.8 b
		3.0 b	F.8	31 b	6.2 b
Mangoes	Organic	2.4 b	F.9	32 b	5.3 c
	Conventional	1.6 a	D.0	64 a	7.7 a
		2.0 ab	E.6	54 a	6.7 b

Identical lower-case letters (a,b,c,d) indicate values that do not differ significantly among individual products.

and four vegetables. No consistent pattern emerged for the produce of one type of farming being preferred over the other (Table 7). While every effort had been made to secure samples for comparison without the intrusion of extraneous factors, this was not always successful. It became apparent only after storage and analysis that some of the compared samples were of different "ripeness." This factor, whether or not statistically significant, was sufficient to swamp any others that may have been present. However, the commonly practiced consumption of conventionally grown produce does not seem to have predisposed the assessors to prefer the taste

Table 4. Unit weight, pH, Brix, total sugars and dry matter.

Product	Unit weight (g)	pH	Refractometric Brix	Total sugars in serum[1]	Dry matter (% w/w)
Tomatoes					
Organic	104	3.99	3.9	2.6	5.3
	**	**	NS	NS	NS
Conventional	121	4.15	3.6	1.9	5.3
Carrots					
Organic	na	6.10	9.0	6.6	nt
	na	NS	NS	NS	na
Conventional	na	6.22	9.0	6.7	nt
Oranges (juice)					
Organic	190	3.39	12.0	8.7	nt
	NS	NS	NS	NS	na
Conventional	170	3.38	11.9	9.0	nt
Grapefruit (juice)					
Organic	453	2.98	10.0	6.6	nt
	*	--	--	--	na
Part-conventional	343	3.04	11.8	7.7	nt
Spinach					
Organic	nt	6.60	nt	0.005	nt
	na	--	na	--	na
Conventional	nt	6.52	nt	0.014	nt
Bananas					
Organic	120	4.92	20.5	20.4	23.3
	NS	NS	NS	**	*
Conventional	120	4.77	18.7	15.2	26.1
Sweet corn					
Organic	0.21	7.26	12.6	0.9	25.4
	NS	--	NS	--	--
Conventional	0.19	7.42	12.6	1.2	23.0
Grapes					
Organic	nt	3.68	18.8	18.2	nt
	na	--	--	--	na
Conventional	nt	3.74	15.4	13.7	nt
Mangoes					
Organic	396	4.29	15.2	9.4	nt
	NS	NS	NS	NS	na
Conventional	445	4.27	16.1	9.7	nt

[1] w/v as invert sugar.

The following abbreviations apply in this table:

na = not applicable * = significant, $p < 0.05$ ** = significant, $p < 0.01$
NS = not significant nt = not tested -- = insufficient data

Table 5. Elemental and anion analyses results.

	% in dry matter			ppm in serum				
	N	P	K	Cl^-	NO_3^-	NO_2^-	PO_4^{-3}	SO_4^{-2}
Tomatoes								
Organic	2.0	0.30	5.1	85	12	< 5	< 10	110
	**	**	*	**	NS	--	--	NS
Conventional	3.0	0.54	7.3	48	20	< 5	< 10	90
Carrots								
Organic	0.8	0.24	4.4	1300	< 5	< 2	1630	1790
	NS	NS	NS	NS	--	--	NS	NS
Conventional	1.0	0.24	4.7	1300	< 5	< 2	1350	1970
Orange juice								
Organic	nt	nt	nt	420	< 5	< 2	730	1200
	na	na	na	NS	--	--	--	NS
Conventional	nt	nt	nt	390	< 5	< 2	420	850
Grapefruit juice								
Organic	nt	nt	nt	280	< 5	< 2	880	480
	na	na	na	--	--	--	--	--
Part-conventional	nt	nt	nt	420	< 5	< 2	660	560
Spinach								
Organic	3.5	0.36	4.8	1200	< 5	< 2	1000	410
	--	--	--	--	--	--	--	--
Conventional	4.3	0.58	5.7	770	< 5	< 2	770	750
Bananas								
Organic	1.3	0.36	1.7	nt	nt	nt	nt	nt
	NS	NS	NS	na	na	na	na	na
Conventional	0.9	0.24	2.5	nt	nt	nt	nt	nt
Sweet corn								
Organic	2.6	0.28	0.7	nt	nt	nt	nt	nt
	--	--	--	na	na	na	na	na
Conventional	2.6	0.62	0.7	nt	nt	nt	nt	nt
Grapes								
Organic	1.3	0.21	1.0	nt	nt	nt	nt	nt
	--	--	--	na	na	na	na	na
Conventional	0.9	0.19	1.0	nt	nt	nt	nt	nt

The following abbreviations apply in this table:

* = significant, $p < 0.05$
** = significant, $p < 0.01$
NS = not significant
na = not applicable
nt = not tested
-- = insufficient data

of that type to that of organically grown produce.

The hypothesis mentioned in the Introduction was not supported by the present results, neither for unit weights (see Table 4) nor for higher contents of sugars, total dissolved solids, and total dry matter, nor for taste. Organically grown tomatoes gave significantly smaller fruit. However, their mean refractometric Brix showed no difference, their total sugar and dry matter contents were uneven and not significantly different, and no appreciable difference was found in their taste quality. The only other significant weight difference was with grapefruit, where the results were the opposite of the hypothesis. For the nonsignificant weight differences, lower weights were found in mangoes, but higher weights in oranges and sweet corn kernels; weights were equal in bananas. From the refractometric Brix tests (Table 4), organic produce gave higher results in four products, equal results in two, and lower results in two. For the total sugar content results (Table 4), organic produce gave higher results in three products, and lower results in six. For the dry matter content results (Table 4), organic produce gave higher results in one product, equal results in another, and lower results in a third. This does not preclude parts of the hypothesis being true for any individual produce (tomatoes?), even if its taste predictions were not met.

The significant differences detected in elemental and anion analyses of tomatoes (Table 5) may be related to the small but significant pH differences found (Table 4).

Table 6. Further fruit "ripeness" parameters.

	Mean pulp/peel ratio	Mean insoluble matter in pulp (% w/w)
Bananas		
Organic	1.71	5.9
	--	*
Conventional	1.40	14.1
	Titrable acidity (% w/v as malic)	**Brix/acidity ratio**
Mangoes		
Organic	0.22	69
	--	--
Conventional	0.19	85
	Titrable acidity (% w/v as anhyd. citric)	**Brix/acidity ratio**
Orange juice		
Organic	1.28	9.7
	NS	NS
Conventional	0.95	12.6
Grapefruit juice		
Organic	1.48	6.8
	--	--
Part-conventional	1.74	6.8

The following abbreviations apply in this table:

* = significant, $p < 0.05$
NS = not significant
-- = insufficient data

Table 7. Summary of hedonic taste differences.

	Difference between	
	% Ratings to overall median	Mean scores
Organic preferred over Conventional:		
Bananas	+42 **	+1.7 ***
Conventional preferred over Organic:		
Carrots	-6 NS	-0.2 NS
Orange juice	-32 **	-1.5 ***
Grapefruit	-2 NS	-0.9 NS
Spinach	-8 NS	-0.7 NS
Grapes	-22 NS	-0.5 NS
Mangoes	-25 *	-1.9 **
Ambiguous results:		
Tomatoes	+5 NS	-0.0 NS
Sweet corn	-2 NS	+0.3 NS

The following abbreviations apply in this table:

* = significant, $p < 0.05$
** = significant, $p < 0.01$
*** = significant, $p < 0.001$
NS = not significant

Higher contents of N, P and K might have been expected in conventionally fertilized crops, but this was not confirmed (Table 5); on the other hand, in no instance was the mean K content of conventional samples lower than in the organic samples.

The negligible content of nitrates and particularly nitrites is satisfying, considering some long term health concerns (National Academy of Sciences, 1981; Breimer, 1982). These results contrast with some others reported (Brugger et al., 1987; Schuster and Lee, 1987). Negative results for pesticide residues were expected and confirmed in organic samples; it is very satisfying that in the conventional samples they were below detection levels.

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World Sustainable Agriculture Network is a computer network linking individuals and organizations working on sustainable agriculture; for information, contact Institute for Agriculture and Trade Policy, 1313 5th St. SE, #303, Minneapolis, MN 55414; (612)379-5980.

Common Harvest: An Alternative Food and Agriculture Directory is available for $9 plus $1.50 shipping and handling from Food Action Network, Inc., 5324 Park Avenue, Minneapolis, MN 55417-1720; (612)822-7607.

On-Farm Testing: A Grower's Guide is available for $1 from Bulletin Office, Cooperative Extension, Cooper Publication Building, Washington State University, Pullman, WA 99164-5912; (509)335-2857.

Soil and Water Conservation Research and Education Progress and Needs: Executive Summary and **Soil and Water Conservation Research Needs,** both published by the USDA Soil Conservation Service, are available free from Jeri Berc, SCS, P.O. Box 2890, Washington, D.C. 20013; (202)720-8578.

Consumer's Organic Mail-Order Directory is available for $9.95 plus $2.50 shipping and handling from California Action Network, P.O. Box 464, Davis, CA 95617; call 1-800-852-3832 or (916)756-8518.

Soil Conservation For Survival, a 420-page book based on an international conference, is available for $30 plus $3.50 shipping and handling from Soil and Water Conservation Society, 7515 N.E. Ankeny Road, Ankeny, IA 50021-9764; call (515)289-2331 or 1-800-THE-SOIL.

Tackling Toxics in Everyday Products: A Directory of Organizations is available for $19.95 plus $3 postage/handling from INFORM, 381 Park Avenue South, New York, N.Y. 10016-8806; (212)689-4040.

Seven Case Studies in Sustainable Agriculture, a report to the Science Council of Canada, is available for $12 from DG Patriquin, Biology Department, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1.

Approaches to Sustainable Agriculture: Seven Case Studies, a summary of the case studies listed above, published by the Science Council of Canada, is available for $7.50 from International Specialized Book Services, Inc., 5602 NE Hassalo St., Portland, OR 97213.

North American Free Trade Agreement: Implications for California Agriculture is available for $15 from the Agricultural Issues Center, University of California, Davis, CA 95616; (916)752-2320.

Integrated Crop Management Resource Notebook, $30, and **Proceedings of National Sustainable Agriculture & Natural Resources Conference**, $10, are available from Center for Sustainable Agricultural Systems, 221 Keim Hall, University of Nebraska, Lincoln, NE 68583-0949; (402)472-2056.

Trying to Take Root: Sustainable Agriculture in the U.S. Heartland is available for $10 plus $2 shipping/handling from Public Voice, Attn. Publications, 1001 Connecticut Ave., NW, Washington, D.C. 20036.

Resources for Teaching Sustainable Agriculture, a supplement to the Wisconsin teachers' guide, **Toward a Sustainable Agriculture,** is available for $2 from Wisconsin Rural Development Center, 1406 Bus. Hwy. 18/151 E., Mount Horeb, WI 53572; (608)437-5971.

Biomass as an energy source for the midwestern U.S.

D.R. Keeney and T.H. DeLuca

Abstract. *Recognition of the environmental costs of fossil fuels coupled with concern over their depletion within the next few decades has broadened the search for alternative energy resources, including biomass energy. Ethanol produced from corn (*Zea mays *L.) grain currently is the primary form of biomass energy produced in the Midwest, but its net energy balance commonly is negative when corn grain is produced under conventional practices. Reducing fossil fuel inputs, particularly for nitrogen fertilizer, will improve the energy balance, but more substantial improvements involve increased efficiency of ethanol production. An alternate source involves fermentation of crops such as sweet sorghum (*Sorghum bicolor *[L.] Moench).*

Other potential biomass energy resources for the Midwest include oils extracted from seed crops, methane from waste digestion, and combustion, gasification or fermentation of woody and herbaceous crops and crop residues. These resources may serve as an energy supplement or a useful energy source for individual farms, households or rural communities. Biomass energy systems in Midwest agriculture must be evaluated regarding their long term environmental impacts and their sustainability. Externalities that must be considered include surface and ground water pollution, soil erosion, and economic and social benefits to the rural community.

Key words: biomass energy, ethanol, sweet sorghum, oilseeds, cellulose, anaerobic digestion

Introduction

Since recorded time humans have relied on plant biomass for energy in the form of fire. In more recent history, fossil fuels replaced plant matter as our primary source of external energy. Consumption of fossil fuels expanded rapidly based on the premise that this efficient source of energy was abundant and readily available. Society now is aware that the supply is finite and that extraction, transportation, and combustion of fossil fuels have become a primary source of global pollutants. With increasing physical and political difficulties associated with fossil fuel extraction, and with worsening environmental problems, renewable energy sources have gained increasing interest.

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Energy derived from biomass has several advantages over fossil fuels, including worldwide availability, low sulfur content compared to coal, and little disruption of the global CO_2 balance because of the consumption of CO_2 by growing plants (Weinberg and Williams, 1990). Biomass energy now accounts for about 3% of total energy use in developed countries, and should increase substantially by the end of this decade (Scurlock and Hall, 1990).

Biomass produced in some cropping systems currently is not used efficiently. For example, the energy contained in the above ground portion of a hectare of corn (*Zea mays* L.) residue following harvest is equivalent to about 250 million kJ (assuming 14 Mg corn residue per ha and a gross heating value of 17,600 KJ kg^{-1} [Abeels and la Neuve, 1986]). However, developing an efficient technique to handle this bulky material for energy production presents many technical problems. The high energy costs to transport bulky crop residues to a processing site clearly reduces their net energy yield and efficiency. Also, there are potential environmental problems when residues are removed for energy production, especially soil erosion and loss of soil organic matter (Larson et al., 1982). Despite these current limitations, biomass as an energy source has potential for the Midwest provided it is produced renewably and sustainably, with acceptable environmental impact.

This paper discusses the principal forms of biomass for energy, including annual and perennial energy crops, cellulosic crop residues, and woody biomass. These energy sources may be converted to usable energy products in several forms, including: ethanol from grains; ethanol from whole plants, crops or residues; ethanol or methanol from woody biomass; oil extracted from oil seeds; fuel for direct combustion; and combustible gasses. We analyze the limitations and possibilities of current biomass production systems and those under development.

Ethanol from Corn Grain

Ethanol produced from corn grain currently is the primary form of biomass energy produced in the United States. Iowa alone consumes about 3.4 million Mg of corn to produce about 1,300 million liters of ethanol (Iowa Corn Promotion Board, 1991). Ethanol is an effective energy source; however, current corn production practices and total available land area limit the efficacy of ethanol production from corn grain.

Energy costs of corn production

Current technology for corn production is energy-intensive. Corn has a high N requirement and generally uses intensive tillage methods. In the Midwest, farmers

used N at an annual average rate of 151 kg ha^{-1} on corn between 1985 and 1989. (In the following analysis, Iowa agricultural statistics will be used as an example for Midwestern corn producing states [Skow and Holden, 1986-1990]). From 1945 to 1983, average N fertilizer applications nationwide increased nearly 20-fold, while average corn yields increased only 3.5-fold (Pimentel et al., 1989a). N fertilizer is highly energy consumptive; producing 1 kg requires about 88,100 kJ of energy (Dovring and McDowell, 1980). This makes fertilizer N the most energy consumptive component of conventional corn production. Heichel (1978) estimated that fertilizer N accounted for over 44% of the total energy input for non-irrigated corn production. Irrigation has been estimated to add approximately 7.4 million kJ ha^{-1} (Pimentel, 1991), a value that varies widely depending on weather and type of irrigation system. Judicious use of N fertilizer will become more important as energy and, therefore, fertilizer costs increase.

We used Iowa statistics on fertilizer and pesticide use on conventionally produced corn, combined with data from Pimentel et al. (1989b), to estimate the energy required to produce corn in the Midwest (Table 1). The energy conversions for fertilizers, machinery, and pesticides are based on Dovring and McDowell (1980), Pimentel et al. (1989b) and Stout (1979), respectively. The estimates of the quantity of corn requiring grain drying and the energy consumed in the process were taken from Pimentel et al. (1989a).

Not included in this energy analysis are the external costs of soil erosion and water quality degradation. Soil erosion on corn fields often is high, averaging 15.4 Mg ha^{-1} in Iowa (Soil Conservation Service, National Resource Inventory, unpublished data, 1987). Nitrate is widely present in groundwater in the Midwest (Hallberg, 1989a), which shows that available soil N often is not used efficiently. Several corn herbicides also have been detected in groundwater in many locations throughout Iowa and the Midwest (Hallberg, 1989b). To date society has not developed a way to account for the cost of these externalities.

Table 1. On-farm energy consumption estimates for conventional corn production in the Midwest.

Practice	Quantity (kg ha^{-1})	Energy Use (10^6 kJ ha^{-1})	Reference
Farm machinery	55.0	6.22	Pimentel et al. (1989b)
Diesel fuel (l ha^{-1})	115.0	5.26	Pimentel et al. (1989b)
N	151.2[1]	13.3[2]	Skow & Holden (1986-1990)
P	63.8[1]	1.68[2]	Skow & Holden (1986-1990)
K	80.6[1]	1.01[2]	Skow & Holden (1986-1990)
Pesticides	3.6	0.36[3]	Coop. Ext. Serv. (1987)
Seed	21.0	2.18	Pimentel et al. (1989b)
Lime	426.0	0.56	Pimentel et al. (1989b)
Transportation	322.0	0.37	Pimentel et al. (1989b)
Drying	3,800	3.18	Pimentel et al. (1989a)
Total	--	34.12	

[1]Fertilizer estimates based on five-year application averages.
[2]Dovring and McDowell, 1980.
[3]Stout, 1979.

The potential of ethanol from corn grain and its disadvantages

Ethanol produced from corn grain has several advantages. As a fuel extender, it reduces our dependence on foreign oil and supplies the U.S. with one renewable energy source. As a fuel additive it decreases carbon monoxide (CO) and carbon dioxide (CO_2) emissions from automobiles (Gushee, 1989; Marland and Turhollow, 1990). Reduced CO emissions are particularly important for large cities, where high levels of CO in the air pose a health hazard to humans. Gasoline blended with ethanol also has a higher octane rating, and thus should improve automobile performance.

There also are several potential drawbacks with ethanol from corn grain. Its production cost is not currently competitive with oil, so that subsidies are needed to encourage production (Kane and Reily, 1989). Adding ethanol to gasoline increases ozone emissions, thus reducing the usefulness of ethanol for large cities (Gushee, 1989). Also, several analyses including this one (Table 2) show that the energy used to produce ethanol from corn grain with current technology exceeds the energy yield (Pimentel, 1991).

Although ethanol from grain is an excellent fuel additive, it will not become a dominant transportation fuel in the United States. If all the corn produced in the United States were converted to ethanol, at most about 15% of current annual gasoline consumption would be replaced under the following assumptions: corn production of 1.71×10^8 Mg (the average from 1986 to 1988; U.S. Dept. of Agriculture, 1989, p. 32); an ethanol yield of 372 l per Mg of corn; and 4.3×10^{11} l gasoline consumed in the U.S. annually.

As discussed previously, conventional corn production requires a large total energy input. Pimentel et al. (1989b) estimated this input at over 33 million kJ ha^{-1}, which converts to 11,900 kJ per l of ethanol using an average corn yield of 7.44 Mg ha^{-1} and an ethanol yield of 372 l per Mg of corn. The energy required for producing 1 l of ethanol from corn (starch→sugar→fermentation→distillation) has been reported to be between 8,300 and 17,800 kJ for large units (Marland and Turhollow, 1991), and 15,300 kJ for smaller units (Lyons, 1983). Marland and Turhollow (1991) consider 13,500 kJ to be the most accurate estimate of the best current practice at commercial ethanol plants in the United States.

Marland and Turhollow (1990) estimate a credit of 2,250 kg l^{-1} for the distillation byproduct (stillage) used as livestock feed.

Table 2. Energy balance per liter of ethanol from conventional corn production.

Operation	Energy consumed (-) or produced (+) (kJ)
Corn production	-11,900[1,2]
Conversion to ethanol	-13,500[3]
Ethanol heating value	+20,800[4]
Stillage credit	+ 2,250[5]
NET	- 2,350

[1]Pimentel et al., 1989b (33 million kJ ha^{-1}).

[2]Skow and Holden, 1986-90 (7.44 Mg corn ha^{-1} and 372 l ethanol per Mg of corn).

[3]Marland and Turhollow, 1991.

[4]Council for Agricultural Science and Technology, 1984.

[5]Marland and Turhollow, 1990.

Despite this credit, producing ethanol from corn grain has a net energy deficit of approximately 2,350 kJ l^{-1} (Table 2). We estimate the total energy cost of ethanol production in Iowa at 70.3 million kJ ha^{-1} based on a five-year average corn yield of 7.44 Mg ha^{-1} (Skow and Holden, 1986-1990). Thus, a corn yield of approximately 9.1 Mg ha^{-1} without additional inputs would be needed to balance this energy deficit.

Conversion of corn grain to ethanol is inefficient for two reasons: only the grain is used in the fermentation, and carbohydrates in the grain are stored as starch. The major inefficiency comes about because hydrolyzing the starch to simple sugars before fermentation is highly energy consumptive (Lyons, 1983). Research to improve the conversion efficiency is underway, but proven technologies are not yet available. More efficient use of process and distillation byproducts would greatly reduce the energy imbalance of ethanol produced from corn and reduce the risk of by-products becoming an environmental pollutant (Coble et al., 1985). Marland and Turhollow (1991) demonstrate a positive energy balance for corn grain ethanol when corn processing byproducts, such as gluten meal, gluten feed, and corn oil, are used efficiently.

Because the debate on energy efficiency of ethanol production is made more obscure by the use of byproduct value, the energy analysis in Table 2 does not consider the complex subject of corn processing byproducts. Analyzing markets and profitability also is complex, particularly if one considers the large amounts produced in large ethanol plants. We therefore have chosen to focus strictly on ethanol using thermodynamic heat values to obtain a mass balance estimate.

A reduction in energy inputs for corn production could also result in a positive energy balance. The primary energy inputs that could be lowered are N fertilizer, pesticides, and fuel for tillage. These reductions also are central to sustainable agricultural systems, which minimize purchased inputs by substituting management. They also stress rotations and crop diversity, use internal resources, and provide for stable rural communities (Keeney, 1989a).

The unpredictable nature of crop production also must be considered when looking at any biomass energy as a fuel source. Corn production in Iowa declined by almost half from 1986 to 1988 primarily because of a major drought (Skow and Holden, 1986-1990). Large annual fluctuations in crop production will greatly affect costs and returns and the availability of any biomass based fuel. To address this issue, Runge et al. (1990) have introduced the concept of demand enhancement for ethanol production, whereby the annual amount of ethanol available would be based on levels of excess grain in the United States. This policy may, however, create problems for ethanol manufacturers, who require a dependable long-term source of feedstock.

Ethanol from Alternative Production Systems

Producing ethanol from corn grown with reduced purchased inputs and from alternative crops such as sweet sorghum are being investigated in the Midwest (Leopold Center for Sustainable Agriculture, 1991). These approaches may prove more economical and more environmentally acceptable than the current system of producing ethanol from conventionally produced corn grain.

Sustainable corn production systems

Although the net energy yield of ethanol from corn grain is negative under current corn production practices, the infrastructure for corn production and storage is in place, and the technology for ethanol production from corn is well developed. Also, corn grain, which stores well once dry, often is in surplus in the United States. However, if ethanol is to be considered a sustainable and renewable energy source, we must strive for a positive energy yield. To do this, producers must reduce their use of N fertilizer, pesticides and fuel, adopt stringent methods to conserve soil and protect water quality, and use sustainable farming systems that maximize use of on-farm resources.

Several studies have shown that legume rotations can significantly reduce the need for N fertilizers (Heichel, 1987; Russel and Hargrove, 1989). Crop rotations reduce pest pressures, thus reducing the need for pesticides (Byers and Stromberg, 1987). A reduction in N fertilizer use will decrease the total energy input, thus improving the potential energy balance for corn grain ethanol production. Managing land to reduce external N inputs and make more efficient use of applied or fixed N also will reduce the potential for nitrate contamination of groundwater, increase soil organic matter, and reduce the potential for soil erosion (Keeney, 1989b). Several studies have shown that crop rotations (including legumes), integration of crop production with animal agriculture, and wise use of animal manures can reduce external farm

energy inputs significantly (Pimentel et al., 1983; Pimentel et al., 1989b; Grundman and Honeyman, 1990; Vinton-Johansen et al., 1990).

Accurate estimates of available N in soil will help farmers avoid overapplication of fertilizer N. A late spring soil test for plant available N has recently been introduced (Blackmer et al., 1989; Magdoff et al., 1990). This test allows the spring flush of N mineralization to take place before the soil is analyzed for available N, so that variation in weather is taken into account, making the assessment of N availability more accurate.

A hypothetical estimate of ethanol production, energy costs, and yields using three production systems is given in Table 3. These estimates show that introducing crop rotations into conventional corn production will reduce the energy imbalance, and that a positive energy yield can be attained with low input corn production. The estimates of Pimentel et al. (1989b) assume that yields are equal for all three systems, an assumption that could be questioned, and that the reduction in energy inputs comes from reduced transportation costs for machinery, fuel and fertilizer, and from reduced on-farm use of fuel, fertilizers, and pesticides. The low input systems involve increased management and labor, crop rotation including soybeans, livestock manure application, a cover crop, smaller tractors, and ridge tillage to control weeds without herbicides. Pimentel et al. (1989b) assume that manure will supply the full N requirement and part of the P and K requirements for corn and soybeans.

Ethanol from sweet sorghum

A significant effort is being targeted toward the use of alternative crops that could be grown in the Midwest and converted to ethanol (Anderson et al., 1991; Lueschen et al. 1991). One promising crop is sweet sorghum [*Sorghum bicolor* (L.) Moench], a hardy crop that could be grown throughout the Midwest (Coble et al., 1985). This crop is grown like corn, but the whole plant is harvested for fermentation, not just the grain. Sweet sorghum could be planted in mid to late May and harvested in mid September, so that it would not interfere with field operations for corn.

The most desirable aspect of sweet sorghum is that it can yield significantly more ethanol per hectare than corn (Coble et al., 1985). Lueschen et al. (1991) recently calculated ethanol yields from sweet sorghum in Minnesota at 3,000 to 4,000 l ha^{-1}. Production of sweet sorghum would introduce an additional cash crop that could be grown in rotation with corn and soybean to increase diversity, help break pest cycles, and further reduce purchased inputs for producing corn. However, soil erosion would still have to be controlled. The potential for soil erosion with sweet sorghum is probably even greater than with corn because of the later planting date, which leaves the soil exposed longer in the spring. No-tillage and appropriate residue management could overcome this problem.

Currently, storage limitations and difficulties in handling probably are the greatest obstacles to the sweet sorghum-ethanol system. Sweet sorghum degrades rapidly in storage, and shipping the low density material to processing plants would increase energy and labor costs. A potential solution is to use locally owned distillation units. Alternatively, individual farmers could ferment the biomass on-farm and ship the liquid elsewhere for refinement. The dry residue could be returned to the soil, burned for energy, used as a livestock roughage, or converted to fiberboard (Lu and Ma, 1989). Efficient technology for a sweet sorghum-ethanol system has yet to be developed (Coble et al., 1985), and further research is needed to determine its efficacy for wide-scale use in the Midwest.

Ethanol from herbaceous crops

Besides starch and sugar crops, ethanol can be produced from the cellulose in herbaceous crops such as switchgrass, (*Panicum virgatum* L.) woody biomass (e.g., *Populus* spp.), and crop residues (Cresta and Giolitti, 1986; Lynd et al., 1991). Lynd et al. (1991) report that from 1.3×10^{16} to 2.8×10^{16} kJ may be produced from cellulose feedstocks in the United States. This is 8 to 18 times greater than the total that could be produced from ethanol from corn grain.

Producing ethanol from cellulosic materials potentially is more energy efficient than producing it from corn grain. Cellulosic materials are more widely available, and the energy input for producing feedstocks is much lower than for corn grain (Lynd et al., 1991). Ethanol from cellulose potentially can meet a significant portion of the total liquid fuel demand in the United States (Lynd et al., 1991). Research is being conducted to develop an efficient enzymatic process to degrade cellulose, which should become economical by the year 2000 (Lynd et al., 1991). Unfortunately, very little funding is available to

Table 3. Energy produced or consumed in ethanol production from corn grown under three management systems.[1]

Operation	Conventional	No-till plus rotation	Low-input
Corn production[2]	-11,9002	-10,900	-5,850
Conversion to ethanol	-13,500[3]	-13,500	-13,500
Ethanol production	+20,800[4]	+20,800	+20,800
Stillage credit	+2,250[5]	+2,250	+2,250
NET	-2,350	-1,350	+3,700

[1]Management systems adapted from Pimentel et al., 1989b

Conventional: continuous corn

No-till plus rotation: corn/soybean rotation

Low-input: corn/soybean rotation with manure applications, cover crop, and ridge tillage.

[2]Corn yield based on a 5-year yield average of 7.44 Mg ha^{-1} (Skow and Holden, 1986-1990) and ethanol yield of 372 l Mg^{-1}.

[3]Marland and Turhollow, 1991.

[4]Council for Agricultural Science and Technology, 1984.

[5]Marland and Turhollow, 1990.

evaluate and develop energy from cellulose and other alternate processes (Flavin and Lenssen, 1990).

Energy from Oil Crops

Since the energy crises of the 1970s, considerable research has been devoted to using oil from oilseed crops as a source of energy. Examples include sunflower (*Helianthus annuus* L.), rapeseed (*Brassica napus* L.), flax (*Linum usitatissimum* L.), and peanut (*Arachis hypogaea* L.). Using oil from crops for energy is not a new idea. An early diesel engine displayed at the 1900 Paris Exposition was powered by peanut oil (Grinaker, 1981).

On-farm oil presses can extract about 85% of the oil from sunflower seeds with a yield of about 400 kg per Mg of seeds (Delorit et al., 1984). This oil may either replace or be blended with diesel fuel.

Plant oil as an energy source has had mixed results. This is primarily because variability among oils, and even within oil from the same crop, harms the performance of a diesel engine. The inefficiency of plant oils arise mainly from impurities and instability (Engler et al., 1985), which can be overcome by degumming. The thermal efficiency of unmodified plant oils is 90 to 110% that of diesel fuel. Their power output may be slightly lower and fuel consumption slightly higher than diesel (Engler et al., 1985). However, plant oils that have been degummed and treated with ethanol or methanol are comparable to diesel fuel in performance (Engler et al., 1985).

The low cost of diesel fuel and the high cost of growing oilseed crops and extracting oil from them make this technology uneconomical (Council for Agricultural Science and Technology, 1984). However, purified oil has been produced on-farm for less than the cost of diesel fuel (Delorit et al., 1984). The economic evaluation included the value of the residue (press cake) as a livestock feed.

Increasing land area to produce oilseeds for fuel introduces some of the same problems discussed above concerning increased use of corn for ethanol production. However, as with sweet sorghum, oilseed crops would provide many Midwestern farmers with alternative crops.

Woody Biomass

Combustion of wood has been a source of energy for humankind since recorded time. At the beginning of this century about 30% of world energy consumption came from wood; more recently wood has supplied about 6% (Stout, 1979). Wood may be combusted directly, fermented to ethanol or methanol, digested to form methane, or burned in a gasification unit.

Woody biomass is available in many parts of the country, but in heavily farmed areas of the Midwest useable woodlots are largely found in riparian areas and on steep slopes. More woody biomass may be available in the future if short rotation wood crops are grown economically. Short-term rotational woody crops (e.g., *Populus* spp., *Acer* spp.) may serve as an alternative crop to be grown on marginal land or woodlands (Mitchel, 1986).

Burning of wood for home heating may be suitable for individuals who live near wooded lots with sufficient stocks of mature trees or who have a source of low-cost wood. Generally, direct combustion of wood for energy is relatively inefficient, and releases a large amount of particulate matter. Wood burning stoves can significantly degrade local air quality. New technologies are being developed that should greatly increase the efficiency of wood combustion and reduce pollutant loads. Woody biomass grown as a crop or produced in buffer strips or wood lots also can be efficiently burned in a gasifier (Stout, 1979; LePori and Soltes, 1985).

Ethanol, methanol, and methane also can be produced from woody feedstocks. Although current production technologies are uneconomical, advances are being made that soon will make these into viable forms of energy (Campbell, 1983; Weinberg and Williams, 1990). Lynd et al. (1991) suggest that ethanol from cellulosic energy crops, conventional forestry, and wastes will be produced at a price comparable to petroleum fuels by the year 2000. Ethanol yields from woody or herbaceous (forage) feed stocks have been estimated at 170 to 450 l ethanol per Mg of biomass (Food and Agriculture Organization, 1980). Techniques are being developed to increase the energy efficiency of wood methanol production through gasification (Larson and Kertamus, 1987). Also, Turick et al. (1991) recently demonstrated high yields of methane from digestion of poplar and willow (*Salix* spp.) trees.

Crop Residues and Herbaceous Energy Crops

Potential and limitations

There is a significant amount of energy in crop residues. For example, one ton of corn residue contains about 17.6 million kJ (Abeels and la Neuve, 1986). About 15% of the total energy that goes into producing a corn crop is stored in the grain; the rest either is lost to the environment or remains in the stalk, leaves, cob, and roots (Stout, 1979).

The energy in herbaceous energy crops such as switchgrass averages approximately 17,350 kJ kg^{-1} (Morey, 1982). These crops can be harvested like forage crops with up to four cuttings each year, giving total gross energy yields equivalent to 117 million kJ ha^{-1} yr^{-1} (based on a yield of 6.7 Mg ha^{-1} yr^{-1}).

Legitimate concerns raised by removing crop residues are that the soil surface is exposed to erosion by rain and wind, and that eventually soil carbon and soil fertility will be reduced (Larson et al., 1982). If crop residues are to be a renewable, sustainable energy source, techniques must be used that maintain sufficient soil cover for erosion control and that return N and organic matter to the soil. This can be partially achieved through conservation tillage, removal of only some of the residue (Karlen et al., 1984), and winter cover crops (Frye and Blevins, 1989).

Crop residues have a lower energy value per unit volume than other common fuels. The energy in corn stover is about 12.5% that of a similar volume of wood, and about 3.1% that of diesel fuel (Council for Agricultural Science and Technology, 1984).

To reduce handling costs, crop residues must be converted to a liquid or gas before transportation. The inconsistent energy content and chemical composition of the different crop residues also limit how they can be used (Council for Agricultural Science and Technology, 1984).

Herbaceous energy crops can be grown in several systems: instead of pasture or

forage crops for livestock; instead of row crops on highly erodible land; or in filter and buffer strips or on field margins. Besides being a source of energy and income, herbaceous energy crops could be important for soil and water conservation (Vaughan et al., 1989).

Energy production from crop residues and herbaceous crops

Energy can be obtained from herbaceous crops or crop residues by burning, anaerobic digestion, gasification, or, as discussed earlier, fermentation to form methanol or ethanol.

Direct combustion. Direct combustion of crop residues has been used successfully to heat grain driers (Council for Agricultural Science and Technology, 1984; LePori and Soltes, 1985; Freely, 1987). An example of such a system is the concentric-vortex furnace (Claar et al., 1982). The furnace can effectively reduce the moisture content of a corn crop by 10% using only about 10% of the cobs. More common systems for combustion of crop residues and energy crops include fixed and fluidized bed furnaces. These may be used in space heating or in steam production for electricity generation (Morey, 1982). Residue burning systems also have been used for institutional and industrial purposes (Freely, 1987). Several innovative systems have been developed for collecting, concentrating, and combusting crop residues (Freely, 1987).

Methane production by fermentation. Methane, in the form of biogas, is produced by the anaerobic digestion of organic matter, including animal or human waste and plant material (Sweeten and Reddell, 1985). This technology has been used throughout Asia and at some municipal and farm sites in the United States.

Methane, the primary component of natural gas, has a heating value of 3,750 kJ m^{-3}. Bacterial degradation of organic matter under anaerobic conditions releases biogas, which is 50 to 60% methane and 40 to 50% CO_2. This process has many benefits, including reduction of total volatile solids of wastes. All forms of plant biomass may be degraded in a methane digester. Corn stover, for example, contains about 93% volatile solids, of which 65% may be degraded by bacteria (Sweeten and Reddell, 1985).

Table 4. Relative heating values for several energy sources (adapted from Lepori and Solts, 1985).

Material	Gross heating value (kJ kg^{-1})
Charcoal	57,100
Utah coal	32,750
Corncobs	26,200
Poplar (*Populus* spp.)	20,600
Maple (*Acer* spp.)	19,800
Corn stalks[1]	17,550
Feed lot manure (fresh)	17,250
Sorghum stalks	15,300

[1] Abeels and la Neuve, 1986.

The efficiency of biomass digestion into methane is limited by the carbon to nitrogen ratio (C:N) of the biomass (Campbell, 1983). If the C:N is above 30:1, the rate of digestion is low. If it is less than 20:1, excessive ammonia may be generated. Since corn stover may have a C:N as high as 60:1, the digestion must be balanced by digestion of enough material with a low C:N ratio such as alfalfa (*Medicago sativa* L.) (Campbell, 1983). Methane can be produced and the slurry returned to the land as an organic matter amendment with little nutrient loss. If loss of ammonia by volatilization is controlled, the digester by-product also is an effective fertilizer (Sweeten and Reddell, 1985).

Several types of anaerobic digesters produce methane efficiently (Sweeten and Reddell, 1985). To make such digesters economical for farmers they must be simple, and several challenges must be overcome: the need for good management, potentially high start-up costs, waste handling problems, high CO_2 emissions and low efficiency or failure of the system in cold weather.

Gasification. Although crop residues have great potential as an energy source, their energy content is low per unit of dry matter (Table 4). Gasification may be an efficient way to liberate energy from biomass.

Gasification converts biomass into a gas at temperatures between 800 C and 1100 C. The gases produced are called low energy gases because their energy value is only about 73,500 to 80,000 kJ m^{-3} (LePori and Soltes, 1985). Therefore they are best used at the site of production (Stout, 1979).

High carbohydrate crops or crop residues could be used for gasification. For example, on highly productive soils, 27 Mg of forage sorghum could be produced per ha, with an energy value of 17,350 kJ kg^{-1}. On steeper slopes and less productive soils, a herbaceous crop such as switchgrass or a rotational woody crop such as poplar trees could be harvested.

Conclusions

A diverse mix of energy sources is needed to reduce our reliance on foreign, nonrenewable, and unsustainable energy supplies. Biomass is an energy resource that can be developed further in the Midwest. Several biomass resources are promising, but for many the technology must be improved to ensure economic and energetic feasibility, and the systems must be examined for their long term sustainability.

Ethanol from corn grain will not be a primary source of energy for the United States. Its development will be limited by the inefficiency of converting corn grain into ethanol and the lack of suitable land for producing more corn than is needed for food. Ethanol from alternative crops or from cellulosic feedstocks such as crop residues is a promising source of liquid fuel. On-farm fermentation or gasification of crop residues and animal wastes is a way for producers to reduce on-farm fuel and electricity expenses. Besides being a source of energy, biomass systems can add

diversity to farms, reduce soil erosion, increase farm income and form an important component of the nation's total energy mix.

There are environmental concerns with development of any biomass energy resource. Many are desirable alternatives to fossil fuels, but some may consume more energy than they produce, resulting in a net increase in fossil fuel consumption and potential long-term environmental problems. Others may result in increased soil erosion and loss of soil organic matter. Renewable resource energy systems must be carefully designed to ensure that they can be sustained without environmental degradation.

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INSTITUTE NEWS

Francis Receives Robert E. Wagner Award for Efficient Agriculture

Charles A. Francis, director of the Center for Sustainable Agricultural Systems, Professor of Agronomy, and Extension Crops Specialist at the University of Nebraska, has received the 1992 Robert E. Wagner Award for Efficient Agriculture. The Award is sponsored by the Potash and Phosphate Institute, and is administered by the American Society of Agronomy (ASA). Dr. Francis is a member of the **American Journal of Alternative Agriculture** Editorial Board.

His educational and research programs focus on design of resource-efficient, profitable, and environmentally sound crop/animal systems that contribute to success of owner/operator farmers, equitable rural development, and quality of life. He is a futurist concerned about global population, resources, and sustainable development.

Over the past two decades, Dr. Francis has co-organized numerous symposia at the annual ASA meetings on topics of resource use efficiency, international education, sustainable agriculture, and innovative approaches to research and education. He is co-editor of a new book series, **Our Sustainable Future**, to be published by the University of Nebraska Press in the spring.

Louisiana State University Economist is IAA Visiting Scholar

Donald Huffman, professor of agricultural economics and noted farm management research leader at Louisiana State University in Baton Rouge, LA, is visiting the IAA this fall, studying the concept of alternative agriculture and identifying the research needed to help farmers and policymakers make informed decisions concerning alternative farming systems. Huffman, who holds a Ph.D. degree in agricultural economics from Ohio State University, has authored or co-authored over 200 articles, bulletins, and other professional reports on the economics of livestock production and related farm management topics.

SARE Program Increasing Interest in Sustainable Ag, Says GAO

The Sustainable Agriculture Research and Education Program (SARE), formerly the LISA Program, "has been a catalyst in increasing interest in and acceptance of sustainable agriculture by individuals and institutions," according to a recently released report by the U.S. General Accounting Office (GAO). **Sustainable Agriculture: Program Management, Accomplishments, and Opportunities** also found "limited guidance from the national office to the regional offices for project monitoring and for reporting program results. In addition, there was little dissemination of project results at the regional and national levels."

The report discusses the USDA's efforts to encourage sustainable agriculture, and makes recommendations to improve those efforts and the SARE program. Single copies of the report (GAO/RCED-92-233) are available free from U.S. GAO, P.O. Box 6015, Gaithersburg, MD 20877; (202)275-6241.

New Plan Outlines Biological Pest Control

A report by 14 distinguished researchers outlines an extensive plan to accelerate the development of biological pest management in California. **Beyond Pesticides: Biological Approaches to Pest Management**, published by the Division of Agriculture and Natural Resources, University of California, is the first in-depth analysis of biological pest management under California's diverse climatic and crop conditions. An executive summary is available for $7, and the entire book for $14, from ANR Publications, University of California, 6701 San Pablo Ave., Oakland, CA 94608-1239; (510)642-2431.

Guide for authors

The American Journal of Alternative Agriculture (AJAA) publishes original research on biological, physical, or social science aspects of alternative agriculture. We particularly welcome multi-disciplinary studies, but papers from a specific discipline also are invited. However, since AJAA readership is much broader than for a single-discipline journal, highly specialized terminology should be explained or avoided. The significance of a statement, or the reasoning behind a conclusion, may have to be spelled out more than in a more specialized journal. See Vol. 5, No. 1, pp 2 & 3, for an explanation of the various categories of articles.

Units

Research papers should use the International (SI, or metric) system throughout. Occasional use of common unit equivalents in parentheses is permitted, mainly for relatively exotic SI units.

Title page

The title page should give the following information (all flush left): 1) title of the paper; 2) names of authors; 3) affiliation and office address of authors, and 4) acknowledgements, if any. See examples in this issue of AJAA.

Abstract

The abstract should be 200 to 400 words suitable for readers from a broad range of disciplines. It should avoid highly-specialized terminology that might be appropriate for a single discipline journal. Take particular care that the significance of the work is made clear, even to readers from a different field.

Key words

Provide subject matter key words suitable for use in scientific indexing.

Reference list

When citing material that has been covered in more than one format, such as the typescript of a conference presentation and a journal article, preference should be given to the version that is most readily available, and that is likely to remain so. Generally this means standard publication channels, such as books, journals, and regular government report series. Unpublished or informally-published material should be cited only when no alternative form exists.

References should be listed in alphabetical order by author's name, and by year for a particular author (with letters after the year if needed). If a sole author is also the lead author of papers with multiple authors, use the following order: single author (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Use initials only for first and middle names. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized. Page numbers are written out in full (e.g., 1108-1123, not 1108-23). The volume is given if page numbers begin at 1 for each issue.

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Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

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Manuscript preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word.

Follow the section headings style used in this AJAA issue. All headings are flush left, with no underlining or italics.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Leave extra space to separate columns. Every figure and table should be mentioned at least once in the text.

Submission of manuscripts

Submit four high-quality copies to Editor, American Journal of Alternative Agriculture, Suite 117, 9200 Edmonston Road, Greenbelt, MD 20770. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form; that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of the family farm.

Low-input alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization set up in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
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